



Folksam Test of
CRSs for Children
Nine Months to
Four Years
2015- 2017

Folksam

This is why we test child restraints

We are committed to what is important to our customers and traffic safety is something that is important for the customers, and especially safety for children in cars. For more than 30 years Folksam has conducted traffic safety research. An area we particularly care for is child safety in cars. We have even during the 90s developed our own child restraint system (CRS) used in a rental scheme for our customers. Based on data from real-world crashes as well as crash tests we have obtained important knowledge on how to protect children in a car crash.

There is a need for consumers to get information on how to best protect children in cars and especially a guidance of the safest child restraints to purchase and use. Therefore, we have chosen to test some common child restraint systems on the Swedish market. In total 22 car seats for children from nine months to at least four years of age were included in the Folksam test. By choosing one of the seats that Folksam has labelled as Good or Best Pick you will allow your child to sit rear facing as long as possible, which is the safest way to put your child in case of a crash.



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Summary

In total 22¹ car seats for children from nine months to at least four years of age were included in the Folksam test. All CRSs (Child Restraint Systems) included in the test have previously been tested and approved according to the CE standard. In Sweden there is a long tradition of having children up to four years of age restrained in a rear-facing position. The benefits of restraining children in rear-facing CRSs in comparison to forward-facing CRSs has been proved by crash tests, as well as real-world crash data. Nevertheless, there is a trend among parents to turn small children forward facing too early. In the Folksam test, the parameters that greatly affect how long time it is possible for a child to sit rear facing as well as functions to protect a child during a collision have been highlighted.

The Folksam test shows relatively large differences between the tested CRSs. In total ten CRSs obtained the result "good" (Axxkid Rekid, Axxkid Minikid, Axxkid Wolmax, BeSafe iZi Kid i-Size, BeSafe iZi Modular RF i-Size, Britax Römer Hi-Way II, Britax Römer Max-Way, Klippan Kiss 2 Plus, Maxi-Cosi Mobil XP och Maxi-Cosi Perl XP) och en som Bäst i test (BeSafe iZi Plus) and one CRS obtained the Folksam "Best Pick" (BeSafe iZi Plus). What distinguishes the best CRSs was that the fact that it was possible to have a child rear facing during a longer period. If a young child (0-4 years) is facing forward the head and neck will be exposed to a higher load during a crash than a rear-facing child. The mass of the head in relation to the rest of the body is much larger for children than for adults. Furthermore, a child's neck muscles and ligaments are not fully developed. The advantage of a rear-facing CRS is that the head, neck and the rest of the body are decelerated at the same time and therefore the load to the head and neck is considerably lower than for a forward-facing child during a crash.

Two of the CRSs included in the test are made only for forward-facing use for child from 9 kg or above: Cybex Pallas and Kiddy Guardianfix Pro 2. These two were poorly rated since they do not comply with the Swedish national recommendation. The recommendation is to keep children in rear-facing car seats at least until the age of four. The reason is that if a child is placed in a forward-facing seat, the child runs five times higher risk of being injured in a crash. Furthermore, in these two CRSs the child is kept in the seat with an adjustable shield over the chest and abdomen. Crash tests have shown that the shield without a harness may not be able to keep a small child within the child seat during crashes that are not perfectly aligned with the front of the car, for example angled or side impact crashes, which then increases the risk of injury. We strongly advise against using these CRSs and we also recommend that the European regulation is changed accordingly.

Six of the 22 tested CRSs were convertible car seats (Axxkid Duofix, Britax Römer Dualfix, Britax Römer Multi Tech II, Brio Zento, Cybex Sirona M2 i-Size and Klippan TrioFix Recline). These received a lower rating score in the Folksam test since we consider that there is risk for misuse. The seats are approved from 9 or 15 kg for forward facing and the design does not prevent the user from turning the child forward facing from a too early age. To put a child forward facing at such an early age is something that we strongly don't recommend

Folksam has conducted this test to give consumers as well as dealers better information on what is a safe CRS so that they can make a correct choice/advice that will allow the child to sit rear facing as long as possible. The legal requirements only cover a limited part of possible crash situations that could cause injuries to a child. The most important factor that characterise a safe CRS is how long time it is possible for a child to sit rear facing. This is not reflected in the legal requirements and here a consumer test like the Folksam test is an important complement. By choosing one of the seats that Folksam has labelled as Good or Best Pick a customer will allow the child to sit rear facing as long as possible.

¹During 2015 in total 17 CRS were tested. Five more CRS were added to the test 2017.

Background – Children Safety in Cars

Children are not miniature adults. Body size proportions and strengths of the muscles, bones and ligaments are different (1). The proportion of the head in relation to the rest of the body is much larger for children, Figure 1. Head injuries account for a higher proportion than for adults (2-4). Children are more vulnerable in a car crash and therefore occupant protection for children needs special consideration. In Sweden the national recommendation for children in cars is to keep them in rear-facing CRSs until the age four or five.

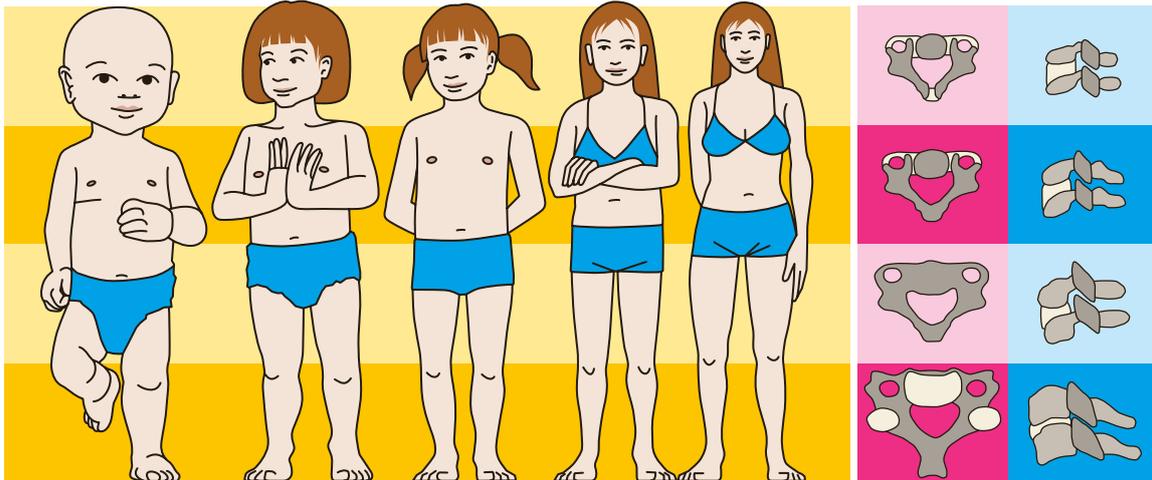


Figure 1. At birth the head is typically 25% of an adult's size, although the body weight of the new-born is only about 5% of an adult weight. Furthermore, neck vertebra, muscles and ligaments are not fully developed.

The advantage of a rear-facing CRS is that the forces are spread over a large area and the head, the neck and the rest of the body are decelerated at the same time and therefore the load to the head and neck is considerably lower than in a forward-facing CRS, Figure 2 (5). Turbell (6) has shown that the load is three times higher in a crash if the child is seated in a forward-facing CRS and the risk for severe neck and fatal injuries increases considerably. Results from frontal crash tests with a car from the early 80's and one from the later 90s shows that the measured force in the neck of the crash test dummy (corresponding to a three year old child) seated in a forward-facing CRS was significantly higher in the newer stiffer car (above 1700 N) than in the older car (950 N) (7). The measured force in the neck of the dummy seated in a rear-facing CRS was below 200 N regardless model year of the car.

The protective effect of a rear-facing CRS is 90-95 percent compared to an unprotected child. In forward-facing CRS, the protective effect is 60-70 percent (8-10). Although, there is a trend among parents in Sweden to turn small children forward facing too early, which means that six out of ten three year old children are seated in a forward-facing position (11). Sweden has been and still is a pioneer when it comes to child safety in cars. The national recommendation is to have children up to four to five years old seated rear facing. To maintain Swedish consumers' awareness it is important to give information about what constitutes a safe CRS.



Figure 2. The load to the head and neck in a rear-facing and forward-facing CRS

Objective

The Folksam test of CRSs aims to highlight the parameters that to a large extent influence how long time it is possible for a child to sit rear facing as well as the CRS's possibility to protect a child during a collision. The objective is also to give consumers as well as dealer better information what constitutes a safe CRS. We also hope that our test will influence manufacturers to design even safer CRSs.

Method

In total 22 car seats for children from nine months up to at least four years of age were included in the Folksam test, Table 1. When choosing CRSs to be included in the test, we looked at the full range available in child safety shops and web shops. Furthermore, we included CRSs that had performed well in European consumer crash test. All CRSs included in the test have previously been tested and approved according to the CE standard.

Folksam has a long tradition of child safety research and we have even developed our own CRSs. Based on data from real-world crashes as well as crash tests we have obtained important knowledge on how to protect children in car crashes. The parameters included in this test are according to us the most important ones. The test of CRSs were partly performed when the CRS was mounted in the front and the rear seat of a Volvo V70, Figure 3. A crash test dummy (Hybrid III), corresponding to a three years old child, was used.

Table 1. Included CRSs

CRS	
Axkid Duofix	Britax Römer Max-Fix II
Axkid Rekid	Britax Römer Max-Way
Axkid Minikid	Britax Römer Multi Tech II
Axkid WolMax	Concord Reverso i-Size
BeSafe iZi Kid i-Size	Cybex Sirona M2 i-Size
BeSafe iZi Plus	Cybex Pallas
BeSafe iZi Modular RF	Kiddy Guardianfix Pro 2
Biltema Bilbarnstol 0-18 kg Art. 39-810	Klippan Kiss 2 Plus
Brio Zento	Klippan TrioFix Recline
Britax Römer Dualfix	Maxi-Cosi Mobi XP
Britax Römer Hi-Way II	Maxi-Cosi Pearl XP



Figure 3. A CRS mounted in frontal and rear seat of a Volvo V70

Included parameters

The following eight parameters have been included in the Folksam test of CRS: Type of CRS, CRS approved for both rear and forward facing, size group, the height of the seatback, leg-room, the tether strap / anti-rebound bar, support leg, possibility to mounted the CRS against the dashboard and the side impact protection.

Type of CRS – forward- or rear facing

The risk of sustaining severe or fatal injuries is five times higher in forward-facing CRS than rearward. The reason for this is that the applied forces to the child body is evenly distributed along the head, neck and upper body, Figure 2. The head of a young child is relatively heavy in relation to the weight of the body. In combination with undeveloped vertebra, ligament and muscles causes larger injury risk than for the larger child. The Swedish national recommendation is rear facing as long as possible, but at least until the age of four to five. To reach best test score the CRS has to be a simple rear-facing seat without possibility to use forward-facing.

Convertible Car Seat

Convertible car seats are designed to be used rear-facing and forward-facing. As a consumer it is tempting to choose one of those CRSs but they have one important shortcoming. The CRS design does not prevent the user from turning the child forward from an early age. And besides, when the child is too large for rear-facing seating, it applies also for forward-facing seating. A better approach when the child is too large for the rear-facing CRS, is to change to a booster seat, more suitable for larger children. The risk for turning the child far too early is substantial in a convertible car seat and therefore these seats will get lower score.

Size group

The Folksam recommendation is to choose a child seat approved for 25 kg in order to enable rear-facing seating for a longer time

Height of the CRS Backrest

To enable usage of the CRS for a long time, the backrest of the CRS needs to be high. In Figure 4 (the figure to the right) the three year old dummy nearly reaches the limit of available space. A rear-facing CRS is too small when the child's ear is in level with the backrest's upper edge of the CRS. The higher backrest the higher the score.



Figure 4. Left: high backrest. Right: low backrest

Leg-room

Generous leg-room is important to achieve rear-facing seating as long as possible. It is not a safety issue to have bended legs but more a matter of comfort. Some parents turn their children too early when they think the leg-room is too small. Leg-room is therefore an important parameter to enable rear-facing for older children. In the Folksam test, the CRSs were installed in a Volvo V70 to measure the leg-room in the vehicle rear seat and at the same time measure the remaining space in the front seat. CRSs with good leg-room without a bulky exterior gives a higher score. This characteristic is beneficial when a large CRS needs to fit in a smaller car.

CRS Installation

One section in the Folksam test is about installation which indirectly is a safety issue. This section contains lower tether straps/anti-rebound bar, supporting leg and possibility to mount the CRS leaning against the dashboard.

Lower tether straps and anti-rebound bar

A rear-facing child in a rear-end collision experience forces which will rotate the CRS towards the vehicle seatback. To avoid this movement you can either use a lower tether strap attached to the vehicle floor pan or an anti-rebound bar against the seat back. Also in a rollover those attachments will prevent the CRS from bouncing around in the vehicle compartment. The presence of lower tether straps and/or anti-rebound bar gives same score.

Supporting leg and front seat installation

In a frontal collision the supporting leg to the floor-pan is important, especially in rear seat, to avoid forward movement. To get highest score the CRS needs to have a supporting leg. The CRS must also allow installation against the dashboard in the front seat. Installation towards the dashboard does not require supporting leg.

Side protection

Side collisions are not as common as frontal collisions, however the consequences are often more severe due to the vehicles lack of ability to absorb energy. In a side collision car occupants will hit the side surface of the car or even the striking car bonnet. In general rear-facing CRSs give better side protection than forward-facing CRSs (9). The reason is that the principal direction of force in a side collision often have a frontal component that forces the child into the rear-facing CRS, Figure 5.



Figure 5. The movement of child's head during a side impact

Side protection is achieved with deep side wings in the head area. It is also preferable with relatively tight side wings around the child head. Figure 6 shows examples of one good and less good side wings. Deep and tight side wings decrease the risk of that the head rotates outside the CRS. The depth of the side wings were measured and compared. The deeper side wings the higher the score.



Figure 6. Left: Deep side wings. Right: Shallow side wings

Results

Eleven of the 22 tested CRSs were classified as good (Axxkid Rekid, Axxkid Minikid, Axxkid Wolmax, BeSafe iZi Kid i-Size, BeSafe iZi Modular RF i-Size, BeSafe iZi Plus, Britax Römer Hi-Way II, Britax Römer Max-Way, Klippan Kiss 2 Plus, Maxi-Cosi Mobil XP and Maxi-Cosi Perl XP), Table 2. These seats fulfil the high requirements of the test covering eight parameters to ensure rear facing use as long as possible as well as high crash protection. Two of the seats tested are only designed for forward-facing children from 9 kg and up; Cybex Pallas and Kiddy Guardianfix Pro 2. Since forward-facing seats have 5 times higher injury risk compared to rear-facing seats for the same size of children these seats came out worst in the Folksam test.

Table 2. Total results for the seats tested. (Maximum 4p)

CRS	Results
Axxkid Duofix	2
Axxkid Rekid	3
Axxkid Minikid	3
Axxkid Wolmax	3
BeSafe iZi Kid i-Size	3
BeSafe iZi Plus	4
BeSafe iZi Modular RF i-Size	3
Biltema Bilbarnstol 0-18 kg Art. 39-810	2
Brio Zento	2
Britax Römer Dualfix	2
Britax Römer Hi-Way II	3
Britax Römer Max-Fix II	2
Britax Römer Max-Way	3
Britax Römer Multi Tech II	2
Concord Reverso i-Size	2
Cybex Sirona M2 i-Size	2
Cybex Pallas	1
Kiddy Guardianfix Pro 2	1
Klippan Kiss 2 Plus	3
Klippan TrioFix Recline	2
Maxi-Cosi Mobi XP	3
Maxi-Cosi Pearl XP	3

Table 3 shows the results for each tested parameter (green = good, yellow = average, red = poor). The seats Axkid Duofix, Britax Römer Dualfix, Britax Römer Multi Tech II, Brio Zento, Cybex Sirona M2 i-Size and Klippan TrioFix Recline scores worse due to the fact that they are possible to use both rear- and forward facing and the risk of misuse is because of that regarded as high. The most covering side impact protection (deepest) was measured in Cybex Sirona M2 i-Size followed by Britax Römer Multi Tech II, BeSafe iZi Kid i-Size, BeSafe iZi Plus and Britax Römer Dualfix. These seats do also have relatively narrow area for the head between the side wings. Klippan TrioFix Recline had the tallest seat back of all the tested seats. Also Axkid Duofix, Axkid Rekid, Axkid Minikid, BeSafe Izi Kid i-Size, BeSafe iZi Modular RF i-Size, BeSafe Izi Plus, Britax Römer Multi Tech II, Klippan Kiss 2 Plus and Maxi-Cosi Pearl XP were considered to have good seat back height. Only one seat, Brio Zento, shall be mounted without a supporting leg. A supporting leg is regarded as preferable.

Table 3. Specific results for the parameters tested (green = good, yellow = average, red = poor)

Model	Weight/ stature	Rear-facing only	Side impact protection	Supporting leg	Space for legs/ space in car	Height of the CRS Backrest	Mounting against dashboard panel
Axkid Duofix	●	●	●	●	●	●	●
Axkid Rekid	●	●	●	●	●	●	●
Axkid Minikid	●	●	●	●	●	●	●
Axkid Wolmax	●	●	●	●	●	●	●
BeSafe Izi Kid i-Size	●	●	●	●	●	●	●
BeSafe iZi Modular RF i-Size	●	●	●	●	●	●	●
BeSafe Izi Plus	●	●	●	●	●	●	●
Biltema 0-18 kg Art. 39-810	●	●	●	●	●	●	●
Brio Zento	●	●	●	●	●	●	●
Britax Römer Dualfix	●	●	●	●	●	●	●
Britax Römer Hi-Way II	●	●	●	●	●	●	●
Britax Römer Max- Fix II	●	●	●	●	●	●	●
Britax Römer Max- Way	●	●	●	●	●	●	●
Britax Römer Multi Tech II	●	●	●	●	●	●	●
Concord Reverso i-Size	●	●	●	●	●	●	●
Cybex Sirona M2 i-Size	●	●	●	●	●	●	●
Cybex Pallas	●	●	●	-	-	●	-
Kiddy Guardianfix Pro 2	●	●	●	-	-	●	-
Klippan Kiss 2 Plus	●	●	●	●	●	●	●
Klippan TrioFix Recline	●	●	●	●	●	●	●
Maxi-Cosi Mobi XP	●	●	●	●	●	●	●
Maxi-Cosi Pearl XP	●	●	●	●	●	●	●

Discussion and conclusions

All CRSs included in the Folksam test have previously been tested and approved according to the CE standard and real-life data show that children seated in CRSs, especially children in rear-facing position (90-95% effectiveness compared to 60-70% in a forward position), are well protected in car crashes. On the other hand there is a trend among parents to turn small children forward-facing too early. Test parameters have been highlighted that have a great influence on how long time it is possible for a child to sit rear facing as well as functions to protect a child during a collision. The Folksam test shows relatively large differences between the tested CRSs.

In Sweden there is a long tradition of having children up to four years of age restrained in a rear-facing position. Therefore, the CRSs that are popular on the Swedish market differ from those in the rest of the Europe. European consumer tests (e.g. ADAC and Stiftung Warentest) primarily evaluate forward-facing CRSs aimed for younger children (1-4 years). As a result of an increase in consumers buying their products on the web there is a concern that forward-facing CRS popular in the rest of Europe will become more common in Sweden. In the Folksam test we have included rear-facing CRSs, CRSs approved for both rear- and forward-facing use as well as CRSs for forward-facing use only.

It is tempting to believe that all CRSs that are approved according to CE standard are safe to use and will provide good protection for young children even if they are seated in forward-facing position. However, the measurements used in these crash tests are inconclusive since only acceleration of chest (max 50 g) and head (max 40 g) are measured but not the neck or load on abdomen. Measured chest acceleration will not show any dramatic differences between rear- and forward-facing CRSs. These tests do not reflect the most important parameters. Head and neck injuries account for the highest proportion of severe injuries to a child (4). Sweden has for a long time been working for an inclusion of neck load in tests for the European regulation without success. To still be able to show the differences between a rear- and forward-facing CRSs Sweden presented a voluntary crash test, "Plus-Test" (previous T approval), where neck-load is measured.

Two of the CRSs included in the test were made only for forward-facing use (Cybex Pallas and Kiddy Guardianfix Pro 2) and were missing a harness. The child is kept in the seat with an adjustable shield over the chest and abdomen. This type of CRS has been test winner in European consumer crash tests but other crash tests with this type of CRS demonstrate that there is a strong possibility of ejection from the seat which then increases the risk of injury (12, 13). Crash tests have shown that the shield without a harness may not be able to keep a small child within the CRS during crashes that are not perfectly aligned with the front, for example angled or side impact crashes. The reason for these CRSs being approved is that neck and abdomen measurements are not included the test for CE approval. We strongly advise against using these CRSs and that the regulation is altered.

All CRSs included in the Folksam test have previously been tested and approved according to the CE standard R44/04 or UN R129 (i-Size). The R129 i Size UN regulation is relatively new and works in parallel with R44 and is only for CRSs installed with ISOFIX. The regulation includes requirements that will give better protection for children in Europe since it is a mandatory rear facing installation until the age of 15 months (previous only 9 months).

An additional improvement is that a side impact crash test is included. The Folksam test shows that most of the CRSs could be better constructed to protect the child's head in a side impact. To protect the head it is important that the CRS's side protection is deep enough and that the CRS is tight around the child's head. Britax Römer Multi Tech II as well as Cybex Sirona M2 i-Size have a relatively tight and strait side protection, which will reduce the movement of the head during the crash phase, Figure 7. In a Swedish consumer's test made by Testfakta the Cybex Sirona M2 got high rating due to good side impact protection.



Figure 7. An example of a good side protection, Britax Römer Multi Tech II

Compared to R44/04 the i-Size (UN R129) child restraint systems uses stature instead of mass. Furthermore, only CRSs that could be installed with Isofix are included. There is an apprehension that the bigger rear-facing CRS that are common in Scandinavia and in particular Sweden will be hard to include in the i-Size regulation. This would worsen the safety for children in Sweden. Representatives from Sweden child safety group have highlighted this(14).

Five of the included CRSs in the Folksam test were approved according to the UN R129 (i-Size). These seats were approved for use up to 105 cm. One would suppose that these have shorter back rests but it was gratifying that these three seats; BeSafe iZi Kid i-Size, BeSafe iZi Modular i-Size and Maxi-Cosi Pearl XP, had back rests higher than 60 cm. The only negative fact is that these seats are approved for 105 cm (approximately 18 kg) which corresponds to the size of an average four year old child. To make it possible to have an older child rear facing the CRS should be approved for 25 kg.

During the beginning of 21 century the number of rear-facing children in Sweden dropped. On a Folksam initiative a joint venture was established and a national policy regarding child safety in cars was created. The policy is backed by car retailers, the Swedish Transport Administration, NTF (the national society for road safety), VTI (The Swedish National Road and Transport Research Institute), manufactures of child restraint systems, Autoliv, Swedish Motor-Vehicle Inspection Companies and Folksam. The aim was: keep children in rear-facing car seats until the age of four. The Folksam test takes its origin from this statement. Moreover, we have used our knowledge from the period when we were developing CRSs of our own in addition to the knowledge we have from real-world crash analyses.

The parameters included in this test are according to us the most important ones. The test of CRSs is mostly based on measurements taken when the CRS was mounted in a car. In Folksam's ranking the focus have been the parameters that have a large influence on how long time it is possible for a child to sit rear-facing as well as the CRS's ability to protect a child during a collision. Factors like washable cover and flame retardant chemicals have not been considered.

The convertible car seats, Axkid Duofix, Britax Römer Dualfix, Britax Römer Multi Tech II, Brio Zento, Cybex Sirona M2 i-Size and Klippan TrioFix Recline, got a lower rating score in the Folksam test. As a consumer it is tempting to choose one of those CRSs but they have some important shortcomings. For Swedish users that have children rear facing up to an older age a convertible car seat will give no further advantage since the child at that time will be ready for a booster seat. The convertible CRSs are approved from 9 or 15 kg for forward-facing use and the design does not prevent the user from turning the child forward facing from a too early age. They rather invite the user to turn the child forward facing. For example with the car seat Britax Römer Dualfix you can with a simple grip turn the child forward facing, Figure 8. From our perspective this is a serious misuse. In some manuals e.g. Britax Römer Dualfix and Brio Zento it is clearly stated that there are great advantages of having the child rear facing and Britax refer to the Swedish recommendation. Folksam recommends all producers to be clear with this in their manuals.

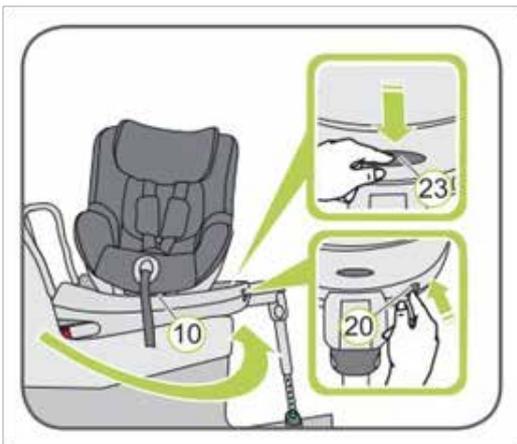


Figure 8. How you easily can transform the Britax Römer Dualfix from rearward to forward facing.

Furthermore, Cybex Sirona M2 i-Size got highest rating in a Swedish consumer's crash test made by Testfakta (2016). A crash test dummy corresponding to a 1.5 year old child was used and the CRS was mounted rear facing. However, the Cybex Sirona M2 i-Size is not classified as Good in the Folksam test since the CRS is a convertible CRS and the backrest is too low. The change that the child is seated forward facing to early is great risk.

Although, there is no regulation stating that young children should be seated rear facing the Swedish traffic safety society has been successful with their recommendations. Sweden is world-leading when it comes to child safety in cars. The first design concept with a rear-facing CRS was created at Chalmers during early sixties and therefore it penetrated the market in a much earlier stage compared to other countries. A high seat belt

wearing rate together with a high CRS use have strongly influenced the reduction of injuries and fatalities among children in cars during the last decades (15). Furthermore, the philosophy behind the Vision Zero has impacted the number of casualties. Safer cars and roads have prevented many crashes as well as injuries. That Swedish young children are better protected in cars is clearly shown in the statistics when comparing Germany with Sweden (16). To be fatally injured in a rear-facing car seat is extremely rare. By studying the child fatalities in cars in Sweden between 1992 and 2011 only 15 children restrained in rearward-facing have been killed. All these were fatally injured due to crashes with big intrusion or by fire or drowning. A Folksam study of all reported car crashes with injured children between the years 1998 to 2010 shows that both the injury risk and the risk of long term consequences are low for young children (4). This is probably due to that the child has been restrained in a rear-facing CRS.

Folksam has produced this test to give consumers as well as dealers better information what constitutes a safe CRS so that they can make a correct choice that will allow the child to sit rear facing as long as possible. The legal requirements highlight only a limited part of possible crash situations that can cause injuries to a child. The most important factor that characterise a safe CRS is how long time it is possible for a child to sit rear facing. This is not reflected in the legal requirements and here a consumer test like the Folksam test is an important complement. By choosing among the best performing CRSs in Folksam's test consumers will allow the child to sit rear facing as long as possible, which enables the best protection in case of a crash.

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