Dimensions and Design of swimming pool fences and balcony and stairs barriers to protect children from falling and from passing trough, bellow or above

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1. PROBLEM

1.1 Background

Climbing is a natural movement. Children often use climbing tasks as a challenge, as it promotes development and skill improvement. They will climb anything that attracts them, making no special distinction for guards or barriers designed to restrict their access to risky environments. These barriers (on balconies, stairs, windows, terraces, galleries, swimming pools) are used to prevent falling from buildings or inside buildings, and to prevent or delay children's access to dangerous places.

There are a variety of regulations and standards for barriers in different countries around the world; some are voluntary, others are mandatory. Yet, discrepancies between standards may introduce additional variability of behaviour and risk perception by parents, institutions, and community. There is no evident scientific support for the standards, but the complete absence of standards or legal recommendations is also unacceptable. Research is required into children's ability to climb different types of restraining devices to argue for appropriate requirements in standards.

Barriers are not a play device, and they must be understood as a limitation (because they constrain behaviour) and as a limit (absolute boundary). Although some morphological or motor skill determinants may contribute to the ability to pass the barriers, the educational role of the family and caregivers is of absolute relevance. In the present research, and strictly for methodological reasons, children were encouraged to pass the barriers. That is the only way to test the overcoming *resilience* of a barrier. The comparisons between barriers, the characteristics of the techniques used by the children, the effects of body dimensions and age, are a natural outcome of the method that we've developed. The findings that we'll report must take the methodological strategy into consideration. In fact, children were asked to do something they know they shouldn't.

1.2 Purpose of the project

The literature research had the objective of gathering information on norms, law, and regulations about fences and barriers enforced in different countries. A preliminary analysis of fences and barriers helped to categorize them following a reasonable classification system. The design of the barriers was analysed from a child safety point of view for the different age groups under consideration. The review of literature also addressed specific concepts that have implications on the issue of child safety.

Subsequent to the literature research we have carried out practical tests with children with the main purposes of: a) finding out different height requirements depending on the age of the child; b) testing some of the most common solutions in what concerns their ability to climb; c) determining which are the main factors associated with the children's ability to pass through, below or above a fence or a barrier. Additional information was provided by selected anthropometric variables.

The ability to pass barriers and fences was assessed by the absolute overcoming resilience and, if possible to overcome, by the time necessary to "conquer" the obstacle.

1.3 Scope

The project focuses on the skills to pass these objects of children aged from 9 to 75 months. The barriers under analysis replicate some of the major types of restraining devices available on the market. For practical reasons a limited number of barriers had to be selected, because the repeated practice of different barriers may introduce learning and adaptation effects. The panels and barriers that were investigated approximately represent the diversity of solutions. It is not possible to represent all available solutions according to fashion, design or other regional specificities.

2. LITERATURE RESEARCH

2.1 Reference values

Safety barriers should be able to prevent falls and to delay children's access to risky environments. To meet this purpose they should be properly designed. Inappropriately designed barriers might not be easily identified by parents or supervisors, who might be mislead to trust in a non existent protection effect of some unsafe barriers, especially when they are new and good-looking. This fact might put children at an even greater risk since their caregivers' supervision might be insufficient. Requirements for different protection devices should be similar, as movement techniques are partially independent of the purpose of the protection. Menezes and Eloy (2007) identified some major problems in barriers construction:

- Insufficient height: in some cases reaching the top of the barrier is an easy task. Children might climb, loose their balance and fall.

- Space between bars: vertical or horizontal bars often have gaps between them that allow children to pass through. In some situations the gap is wide enough for the child's chest to pass trough but not wide enough for the head, this might cause strangulation if the child's body slides down and the head is entrapped (i.e., head entrapment by feet-first action, see Fig. 1). Head entrapment might also occur by head-first, this generally occurs when children place their heads through an opening in one orientation, turn their heads to a different orientation, then are unable to withdraw from the opening.

- Advanced (outwards) guards , outside the building profile: guards can have a space between them and the front wall of the building or the edge of the balcony floor. Children that walk or crawl in a balcony with that type of protection might easily lose support of their feet or hands and a total or partial fall might occur.

- Handholds and footholds: many balconies are designed with gaps in their structure or may have chairs, flowers, plants or other decorative elements in the vicinity, that provide good support if a child wants to climb.

Figure 1 - A gap of 11 cm allows the child's body to pass entrapping the head.

The design of good barriers has probably the same cost as the design of unsafe barriers, but safe barriers will save lives and money spent on fall related injuries. Some aspects of barrier design are discussed next.

Maximum height of a barrier – measured from the floor to the top of the barrier.

The value for the height of the barrier is frequently defined in the interval from 0,90 m to 1,10 m. Despite these values there are some cases were we can see extreme values as 0,70 m (French Standard for non housing barriers with top $\geq$ 0,60 m) and 1,40 m (Italian Standard).

The French standard (NF P 01-012), for example, makes the distinction between housing building (with the minimum of 0,80 m) and other buildings (defined to 0,7 m). In Portugal, the Portuguese association for child safety (APSI), advises a minimal height of 1,10 m free of support points (e.g., footholds) (Menezes & Eloy, 2007; APSI, 1998).

Maximum Gaps – It is defined by the opening between two elements of a barrier.

This dimension could be defined with the help of a good anthropometric data base, supported by an ergonomic definition of free space. If we guarantee that the smallest children cannot pass trough the gaps we assure that the bigger ones cannot pass either.

The standards for recommended spacing for vertical bars vary according to different recommendations in different countries. Culvenor (2002), analysed data from Australia, New Zealand, the United Kingdom and The United States of America, and found differences in recommendations for balconies between 70 mm and 127 mm, and between 89 mm and 125 mm for playgrounds and pools (see Table 1).

Table 1 - Recommended spacing for vertical bars in barriers from various sources (adapted from Culvenor, 2002, p. 3).

Balconies, etc.	Playgrounds, pools, etc.
127 mm max	125 mm max
125 mm max	100 mm max
100 mm max	89 mm max
90 mm max	
80 mm max	
70 mm max	

The reference values indicated in Table 1 report to 2002. Presently, the most frequent measure found is 0,10 m. However, for children under 3 years-old a standard of maximum 0,09 m would be safer in order to prevent partial falls (Menezes & Eloy, 2007; NP EN 1176-1, 1998; CEN Report, 1999). Exceptions are also found in New Zealand, for example, where 0,13 m for older children is acceptable (New Zealand Building Code).

In CEN TC 252 dealing with child use and care articles 65 mm is always used as a distance that should prevent a child's torso slipping between bars leaving the child's body weight being supported by its neck and thus a strangulation hazard. This 65 mm should also be the maximum distance between the lowest horizontal component and the floor/ground.

Stephenson on his book "The Silent and Inviting Trap" (1988) even states that "All Children under 6 years old, will easily pass trough a gap of 0,15m".

On the other hand, specifications for gaps between horizontal bars are sometimes quite permissive. For example the French NF P 01-012:1998 (adopted by Portugal in 2005 as a voluntary technical specification) states the dimension of 0,18 m, if the gap is ≥ 0,45 m above the floor, being one of the most permissive regulations.

Maximum clearance between the lowest horizontal bar and the floor – It is defined as the maximum gap between the floor and lower part of the barrier.

The main danger in this dimension is to ensure that children do not fall or get their head trapped, causing a trauma situation for children. If the child is sitting and slides with the feet first, there is an actual risk of falling or getting hanged by the head. The dimensions observed varied from 0,03 m to 0,12 m, although for example the Spanish Building code would state for the 0,10 m (UNE 85-237-91). In Portugal, the technical specification LNEC E 470-2005 allows distances of 0,11 m. As previously mentioned, APSI advises for a maximal distance of 0,09 m to avoid situations as seen in Fig. 1 (Menezes & Eloy, 2007). Sometimes the lower part of the barrier is advanced from the front wall of the building. In those situations it is also advisable a maximal distance of 0,09 m to avoid entrapment or even smaller to reduce the risk of falling objects. Many international regulations don't allow more than 0,05 m in these situations (Menezes & Eloy, 2007).

Footholds, toeholds and handholds – They are defined by the dimensions outlined for the hand/ toe grip and for the foot support used for climbing a barrier.

These elements facilitate the climbing of a barrier. To prevent this, when barriers have decorative elements that provide a good support point if a child wants to climb, they must be covered with a solid panel from the inside with a minimal height of 1,10 m to avoid the support of hands or feet, in order to difficult the transposition. This panel can be transparent for aesthetics purposes (Menezes & Eloy, 2007).

When parents and caregivers perceive a deficit of safety they frequently try to compensate for that situation adopting inappropriate measures such as covering barriers with inefficient malleable nets, which are often poorly fixed; or placing solid protections that difficult rescue in case of fire. This type of solutions, which cause a risk situation not only for children but for the whole family, could be avoided through the implementation of an adequate building code. Options to compensate for incorrect protection devices may be catastrophic, but unfortunately they cannot be avoided. Regrettably, the compliance with the existing building codes doesn't necessarily state that a barrier meets its safety purposes. Permissive building codes allow for almost every type of barrier, as we can see by the photos presented in Appendix 1.

2.2 Morphological Characterization

2.2.1 Growth from 6 months to 6 years

Human growth evolves in a non linear manner alternating great accelerating growth periods with accentuated proportional disharmony periods, with phases of growth slowness where proportional harmony increases. This temporal growth sequence is fundamental for human organism efficient management of its energetic reserves for growing. Consequently, bigger morphologic growth stability moments (greater proportional harmony) are the most favourable for the occurrence of other learning (e.g. motor abilities, reading, etc.) processes.

The acquisition of motor skills, the development of physical capacities, and the capacity to explore the involving environment is, therefore, a direct consequence of maturity and physical growth.

During first infancy, especially in the first two years, growth speed is very high and morphologic alterations are very fast. Between 3 and 5 years, the growth speed gradually decreases and we can affirm that this period is a developmental phase when children “recover energy” before and after two periods of great growth acceleration, 1st infancy and adolescence.

During the first two years of life weight augmentation is proportionally superior to height increase. This difference is especially critical during the first year when weight increase is approximately 150%-200% and stature increase is only 50% (Tanner, 1962; Sparks, 1992). Stature increases 113% until 5 years (Roche & Malina, 1983). At one year of age, the child total length is 24 cm larger than birth length, and in the second year stature increase is only 9 cm (Jordan, 1988). Despite the growth speed decrease at 5 years, stature increase is still significant, being about 7 cm. From this age until adolescence stature will increase around from 4 to 6 cm each year (Tanner, 1962).

Near-born body proportions reflect intrauterine growth and basically the directions the growth occurred (cranial-caudal versus proximal-distal). Although in the first infancy initial stage there is a predominance of the head comparatively to the trunk and of the trunk relatively to the limbs, the differences between these segments reduce until 3 years of age due to the quick stature growth that occurs during the first two years of life, growth acceleration of the lower limbs.

Initially, the upper limbs are dimensionally superior to the lower limbs. This is a characteristic of first infancy. But from this point on, the tendency is inverted as the lower limbs start growing faster. According to Brandt (1984), since birth until twelve months, the relative proportions of the upper limbs remain rather constant (41%) but the relative proportions of the lower limbs increase from 33,7% to 37% of the child total length, respectively at birth and at the end of the first year.

The enlarged head dimension that is a distinctive characteristic of the children's first year is the consequence of the high girth growth of the head speed during the first months. Throughout the first semester the head girth increases 9 cm, at an average monthly growth speed of 1,5 cm, and during the second semester it only augments 3-4 cm, going from 34-35 cm at birth to 43-44 cm at six months and to 46-47 cm at twelve months (Jordan, 1988; Vaughan et al., 1979).

In near-born and in the first infancy initial phase, despite the predominance of the abdominal region, there is not a clear differentiation between abdomen and thorax. The trunk is cylindrical due to the feeble development of scapular girdle and the great importance of the subcutaneous fat of the hips. The shape of the thorax is also characteristic, being rounded due to the dimensional similarity between the anterior-posterior and transverse diameters and becoming oval when the transverse dimensions begin to grow at a bigger rhythm than other anterior-posterior dimensions. In this phase the difference between biiliocristal or trochanterion and acromiale breadth is still small even if it has bigger increments relatively to thoracic and pelvic breadths.

In the beginning of the second infancy the trunk finally loses its predominance and progressively gains a trapezoidal form due not only to the biacromiale breadth speed growth increase relatively to the trochanterion breadth, but also owing to the accentuated decrease of the abdominal circumference. At the same time, muscular forms become visible.

During the first 5 years of life trunk length increases about 14 cm (Dermirjian, 1980, cited by Roche & Malina, 1983) or 15 cm (Brandt, 1984), representing about 56% of the child's total length at the age of 5 years.

The morphology we have just described for first infancy has repercussions on children's mobility. In these ages the eye-hand coordination and the objects' manipulation is a consequence of the advancement of the upper limbs growth and of the enormous growth speed of the central nervous system. The rounded forms facilitate the child's first body manoeuvres and axial orientation, such as turning and rolling movements, are easy. Creeping, crawling and sitting are easily supported by limbs proportions and by progressive trunk and neck muscles. Walking would be a much more complicated task if the lower limbs were not so short and the transition between sitting and standing would be highly complex (Vieira & Fragoso, 2006).

The low location of the gravity centre is extremely important to the acquisition of multiple motor tasks. While gravity centre at birth is situated approximately 20 cm above the trochanterion, in adult age it is only 10 cm above the same bone. This small difference of 10 cm corresponds to completely different anatomic positions. At birth it is situated at the xiphoid process while at an adult age it is located at the level of the iliac crests or in the 2nd or 3rd sacral vertebra. The high positioning of the gravity centre explains the difficulty that children of these ages have to get completely immobilized after a run (Payne & Isaacs, 1995), and may contribute to the steadiness and balance deficits that can be easily observed.

Another aspect is that, as countries develop in so many different ways, the growing rates in different countries are also very variable. Secular trend, for instance, are perhaps more influential than traditional race differences. Secular trend in China and Southeast Asia as well as in other emergent countries, acts upon children's morphology in a striking way. Normally, secular trend shifts toward a growing dimension, but the trend can also be negative, as demonstrated in countries with serious developmental and economic negative growth.

2.3 Trends in motor development

2.3.1 Acquiring new skills

2.3.1.1 Perceptual development

Babies, infants and toddlers, share a common feature: their perceptual systems are learning to deal with huge amounts of information, bringing pieces and details together, into unified and unique representations of the world. This developmental trend requires sensorial maturation, environmental stimulation, and opportunities to learn. The process of learning how to interact with the environment is a perceptual as well as a motor process. Perceptual development requires maturation support, but cannot be fully explained by maturation. In fact, experience increases acuity of perception, and experience requires action.

Vision plays a major role in this process. As a matter of fact, all senses demand information exchanges with the visual system in order to calibrate all perceptual systems. That happens with auditory, vestibular and tactile information, in a process that origins the perception of a body within an environment, and of a body that moves in that environment. During the first years of life some visual aspects develop very rapidly, such as visual acuity, visual accommodation, peripheral vision, fixation and tracking of objects. For the purpose of this report it may be interesting to focus on depth perception – the ability to judge distances from objects and surfaces (Williams, 1983). It has two basic and distinct forms: the static depth perception that informs about static features of the world, and the dynamic depth perception, that concerns moving objects, moving bodies or both. The visual cliff experiment (Gibson & Walk, 1960) demonstrated that crawling children can visually perceive depth at an edge and behave accordingly. But other studies (Svedja &

Schmidt, 1979; Berthental & Campos, 1990) have shown that there is a clear distinction between locomotor and pre-locomotor children in what concerns the physiological and emotional responses in that experimental condition. The experience of locomotion offers a child a realistic meaning of the situation that was not observed in pre-locomotor children, suggesting that depth perception is a function of experience and not a simple natural consequence of maturation processes.

Visual information, the optical flow to be more precise, dominates the vestibular and the somatosensory information from muscle sensors (that became evident in the "moving room" experiments after Lee and Aronson (1974)). This means that visual information that comes from moving objects, or information produced by moving around or over objects, plays a major role in the organization of posture and the conservation of balance (Thelen, Ulrich, & Jensen, 1989). When passing obstacles or barriers, much of the required coordination is not body-dependent but visually-driven, and that is a problem in early childhood years, when the correspondence between visual flow and other sources of information is not fully established. Once again, the most obvious way to solve this problem is to provide additional experience in these kinds of situations. Keep in mind that barriers may not act as an efficient dissuasion tool; if the child attempts to climb them, the minimization of the risk of falling must also be observed.

In the young infant, some of the most relevant acquisitions are self-perception, the perception of distance and position, the perception of motion and movement, the perception of weight and height.

In the first year, and to be more precise until the onset of walking, the world is perceived as a support surface in which creeping and crawling can take place. In this perceptual world, walls and furniture set the limits for locomotion – they offer the boundaries for a new set of actions, like standing and walking. Vertical boundaries, in particular, are very powerful: they usually do not afford passing over, although they may afford passing under and passing through. Yet, as the perceptual system is rather limited, the correct assessment of body possibilities involves great error margins. Decision making involves a high risk of failure for maturation, perceptual-motor and cognitive reasons.

Accidents are a strange combination of curiosity and mistake: the child's most relevant characteristic is the enormous curiosity about things and finding new possibilities is a never ending story. However, as the sensory and neural systems are not fully mature, a considerable amount of functional error is always present. Estimates of distances and weight are so frequent that collisions and manipulation errors are a natural part of children's daily life. At this moment in life, falling is of limited consequences, because the centre of gravity moves very close to the ground. That will not be the case in older "walking" or "running" children. When falling from upright standing posture, body shape and fat tissues will offer natural protection.

Natural limitations of crawling movement and quadruped posture do not allow a significant climbing experience. Instead, the common use of four limbs in locomotion tasks is a natural limitation to the involvement in risky tasks. Arm strength, and specially a poor strength/weight ratio, act as biological limitations for dangerous climbing experiences.

At the onset of walking everything changes dramatically: a limited support basis and a vertical structured world will replace the former safe *ground world*. Hands can operate with greater autonomy and the perceptual world changes very rapidly – new properties of objects and new spatial relationships feed the brain with a strong, fast and flowing information array.

One of the consequences of this perceptual spurt is that action possibilities suddenly improve but the expected sensory consequences of movement are not tuned with action. During the first year of life a sort of (lovely) characteristic jerk can be observed. In older children that characteristic will not be appreciated, for unexpected consequences of jerky actions can be quite dramatic. The anticipatory control of movement, the additional use of feedback information, and the automatic regulation of movements will progressively reduce jerk. For practical purposes, and as a general principle, don't forget that movement experience reduces jerk.

2.3.1.2 Rudimentary skills - Transitional skills

It may seem strange, but new walkers have an increased potential for accidents. As we have seen before, they have new capabilities that they don't master and the anticipation of action outcomes is rather limited. During the second and third years of life the body learns to operate with these new possibilities, developing some rudimentary skills of great importance. The rapid development of higher cognitive processes, associated with increased motor ability, causes rapid (and sudden) changes in this period (Gallahue, 1989).

In the locomotor domain, running and jumping skills are crucial. These movement structures are slowly mastered, but the potential for acting in the world is dramatically altered. Children learn to respond with adaptability and versatility to a variety of external conditions. Combining running and jumping, a common feature in the second and third year of life, allows for the ability to pass vertical walls that were not passable before. Jumping and climbing can be coordinated in complex combinations, and the maximum reachable height "moves" to new standards. Almost everything in domestic areas can be reached and every obstacle may become a challenge. Curiosity has now a new ally: an increased action capacity.

Manipulation, that used to be of a very simple and limited type, is now a powerful resource. Hands can move very rapidly, fingers can operate with dexterity and strength increases. The coordination of both hands can maximize grasping and throwing, and objects can now be operated in very dangerous ways.

Children can now hang on bars, swing and jump, and develop infinite movement combinations. Movements are so rewarding that children repeat them time after time, developing new skills of high complexity. The repetitive nature of movement, and the observation and modelling of peers, combine in such a way that new solutions are continuously discovered. These skills are not a direct and simple consequence of maturation: opportunity for practice, modelling and peer confrontation, and parents encouragement are necessary, in order to achieve highly structured skills and a clear and sharp perception of movement outcomes and consequences.

Many studies have demonstrated that motor performance grows rapidly before 3 years of age. A new consolidation phase can now take place, in which the combination of basic skills in the domains of posture, locomotion and manipulation, transforms the developing organism into a *problem-solving specialist*. By definition, five-year-old children can perform all human basic movements, although performance may change for structural reasons. In fact, significant changes are about to occur in the domains of body growth, mechanic and energetic efficiency and coordination. It is universally recognised that, in movement education, practice makes perfection. Play will develop new symbolic dimensions, peer relations, and sophisticated structures. Most skills will be inserted in play activities, giving origin to more complex games and reinforcing the development of skills. Movement skill that used to be of a functional nature, is now deeply surrounded by pleasure and emotion. Emotional thinking and competition with peers brings new safety challenges.

Contrary to common opinion, play happens in every context and not only in the so-called play spaces. Many activities that show no purposeful behaviour are in fact play activities, as serious as play can be. Unfortunately, parents and caregivers cannot fully address the nature of children's play: play is an attitude, a challenge and a discovery – play can happen everywhere, and it does.

2.3.2 Physical growth and motor performance

2.3.2.1 Climbing skills

Children have an inner urge to climb and improve their motor skills. Little children climb on an object just because they have an intrinsic need to explore their surroundings and develop their motor skills in every possible way. Climbing broadens children's play possibilities. By climbing they can reach new places and see new things, in a challenging way. However, the need for new experiences and the accurate perception of action limits are two separate things. Children still have to learn by experiencing what is possible and what is not, and they inevitably will have accidents as a result of unsuccessful attempts. Reduced strength and strange body proportions do not favour climbing. In the long term they will learn to judge their capacities, they will become more careful and cautious, and little accidents will tend to disappear.

Pivoting may be observed in 3 month-old children (less than 5%) and 50% of all children can pivot before 6 months (Piper & Darrah, 1994). Four point kneeling may be observed at 5 months (10%) and at 7 months 50% of all children can use this locomotion technique. Less than 10% of all children can exhibit a reciprocal creeping technique. These chronological standards indicate that the motor competence for locomotion in small distances may be available before 6 month-old. This information implies that protection for gaps must be attended before the first half of the first year.

From the moment toddlers start to pull themselves up they start practising their climbing skills. Strong and light children are normally better climbers since a basic need for climbing is that the child has the strength to carry his/her own weight. At the age of 6 most children have the skills to climb as an adult. They have similar proportions to an adult, and because they are still small and lightly built they are often better climbers than older people. Until the age of 4 boys and girls do not show significant differences in climbing skills. After this age the boys are developing more strength than girls (van Herrewegen, Molenbroek, & Goossens, 2004).

The ANEC R&T Project (van Herrewegen, Molenbroek, & Goossens, 2004) has identified some influential qualities for climbing: age, height, weight, strength, character, leg length, arm length, grip, grasp, step height, and flexibility. Despite the fact that clothes and shoes do not seem to significantly influence climbing skills in children, they can be the cause of severe accidents. The same report also states that the climbing skill may be influenced by talent (1/3) and by the environment they live in (2/3). It also underlies the fact that good climbers can be recognised when they are still young. They move very easily and relaxed, they can look around and concentrate on a lot of things at the same time while climbing, they take alternating steps, they do not necessarily stay close to the object, they like to climb, and choose automatically the best climbing technique for each object.

The properties of the object also influence its *climbability*. Some influential characteristics are: existence of footholds or handholds, height of the first support point, distances and angles between support points, shape of the support points, roughness of the material, and slope of the surface.

When trying to climb an object, children usually look for a horizontal bar, rail or any other thing they can grab. They pull themselves up with their arms while looking for footholds and support points for their hands. While climbing a wall or a fence they sometimes use their knees and elbows as well. To get on top of an object they throw one leg over the edge of the horizontal support or they push themselves up until they are able to put one foot next to their hands. The first seconds at the *top of the world* may be very dangerous because posture and equilibrium are precarious.

The ANEC R&T Project (van Herrewegen, Molenbroek, & Groosens, 2004) presents a developmental sequence of climbing skills (see Table 2).

Table 2 - Developmental sequence of climbing skills
(adapted from Herrewegen, Molenbroek, & Groossens, 2004, pp 20-21).

Age (years)	Climbing behaviour	Safety concerns
1 - 1,5	Pulling themselves up on rails and edges of furniture, starting to walk, small steps of about 20 cm (stairs and mattress), crawling over small bumps and low obstacles.	They do not see any danger and do not yet know what height means.
1,5 – 2	Walking gets better, climbing on a slide and sliding of, more high steps (foot after foot), stepping over something, trying to keep their balance.	Children do not yet know their own boundaries.
2 – 3	Climbing higher, more balancing.	Children start to know what is possible and what is not and most of all what is allowed. They have little or no fear for heights.
3 – 4	Good balance, jumping of objects, hanging on, sitting on small object.	Children become a bit frightened sometimes: difference between good and bad climbers becomes bigger.
4 – 6	Children are developing all aspects of their motor skills. They can climb the stairs alone. Once they are 6 years old most children can move as adults and they are starting to learn more difficult movements like riding a bicycle with two wheels. Some of these children are able to climb a rope but most can not do this yet. Until this age there is little difference between boys and girls.	Children are a bit frightened but not very scared of heights. Parents will often still come with them when they play outside to keep an eye on them.

Age (years)	Climbing behaviour	Safety concerns
7 – 9	Children like to play fantasy games. They play a lot outside the house without someone watching them. They like to climb on playground equipment and are experts at finding new ways to do this. A lot of them can still not climb a rope. Some of them because they are frightened, some of them because they do not understand the technique of using their legs and some of them because they are too heavy and they are not strong enough to carry their own bodyweight. Their body mass is becoming more important for the ability to climb.	At the age of about 9-10 years children start to understand what height means. From this time on some kids can become more scared of heights than they were before. Especially girls can show some regression in climbing skills at this age.
10 – 14	Children of this age are starting to play more sport games. Puberty will start around the age of 12 and this will change a lot in the lives of the children. Some of them will have to get used to their new body forms and will become averse to physical movement. Differences between boys and girls are becoming bigger. Boys are getting stronger.	As adolescents the children will climb a climbing frame or other objects but they do not play on it, they use it as a place where they can sit and look over the area whilst talking to each other. The chance that they will fall from the object is therefore very small.

A very limited number of studies using acceptable scientific methods and focused on children's climbing ability was identified. Rabinovitch, Lerner and Huey (1994) examined children in the age range of 24 to 54 months in a climbing task with commonly used fences, up to 5 feet height. The results observed in the highest fence (5 ft) showed that the older group (48-54 months) ranged from 8 to 100 percent success rate. Only one fence (ornamental iron fence) offered more than a 90% restriction rate. In this age group, three of the five tested fences were crossed with a success rate of more than 55%. Two fences offered more than 80% success rate. Three-fourths of the children in the youngest groups were able to climb the common chain-link fence at 4 ft.

On the other hand, 4 feet fences seemed very effective in preventing younger children's (24-36 months) climbing behavior. At this age group, 60% of all 4 ft high fences offered total security (no crossings at all). In this study the time to cross the barriers was also analyzed: the 4 ft fences were crossed in less than 76 seconds (in average) by children of all age groups. This means that some fences were effective in preventing crossing, but if the child can cross it then the time they need to do it is very short. In the older group all children that crossed the fences did that in less than 25 seconds. An analysis of the overall time to cross 4-ft barriers, considering all children that could do it, showed that the children who successfully climbed the fences did so quickly, "providing additional reason for concern about the effectiveness of fencing" (p.740). As expected, there were statistically significant differences in the time needed to cross different barriers.

In this study a roller top and an angled plate top barrier were also tested and the results indicated that they significantly reduced crossing success. In the common chain-link fence the roller top design wasn't so effective in the older group tested (42-48 months) since children had a greater success rate with this retrofitted profile than with the wide-angled plate. On the other hand, in the stockade fence the roller top was more effective since no children in the older group could cross it. Time to cross these barriers was not significantly different from time to cross more conventional fences.

Nixon, Pearn and Petrie (1979) tested vertically ribbed barriers, with horizontal rib spacing of at least 0,91 m, ranging from 0.61 to 1,37 m, in a sample of children up to nine years of age. Results showed that 80% of the two-year-olds did not climb the 2-ft fence, but 50% of the 3 year-old children could climb a 3-ft fence, and one fifth of the three-year-olds could climb a 4-ft fence. The effective protection of this kind of barriers, despite their height, is very low.

Another study that analyzed children's ability to climb was focused on stair guards of 0.90 m (Riley, Roys, & Cayless, 1998). Interestingly, the authors presented a flowchart showing the events leading to a child climbing a stair guarding that included, among other variables, the following morphological items: height, leg and arm length, and strength. In the conceptual framework they also included factors affecting the desire to climb, such as personality, maturity, and desire to experiment, as well as restrictions to climb (guardian behavior, permission to climb, belief in ability, etc.). The results indicated that the time children need to cross the guard is very short (mean climbing time was 13,2 seconds, with a range of 3,2 to 40,9 seconds). The authors have identified three climbing strategies and showed that, in a natural-ecological experiment design, younger and smaller children imitated their older and taller mates. Imitation and influence of older mates is a very interesting factor, because in natural conditions in the home environment older brothers and sisters influence the climbing behavior of their younger siblings. Boys and girls behave differently: boys were more oriented to try climbing behavior, and this fact may be the origin of frequently reported gender discrepancies in epidemiologic based reports.

2.3.2.2 The development of strength

Strength is fundamental to motor performance. Many skills, such as climbing, require a minimal level of strength and can be better performed by strong children. Even daily activities become difficult without enough strength (e.g., older adults who have lost much of their strength might have difficulty climbing stairs, being often at a greater risk of falling).

Muscle strength is related to muscle size or muscle mass, in particular to physiological muscle cross-sectional area. However, changes in strength do not always parallel changes in muscle size, since other factors, such as neurological changes over life span, influence muscle strength (De Ste Croix, 2007; Haywood & Getchell, 2001). Many factors seem to interact to produce the expression of strength (see De Ste Croix, 2007 for a review). Body awareness, neurological, hormonal, age and sex associated changes in muscle strength are important during life span. However, while there is vast literature focusing on determinants of strength development, few studies have investigated common age ranges, muscle groups, testing protocols and muscle actions, making comparisons difficult. Despite this lack of consistency, the age-associated development of strength is reasonably evident, irrespective of the muscle group or action under examination.

As children grow older strength increases steadily (Haywood & Getchell, 2001). Boys and girls have similar strength levels until they are about 14 years where it begins to plateau in girls and a spurt is evident in boys. The exact age in which sex differences become apparent appears to be muscle group and muscle action specific. There is also a suggestion that sex differences in upper body strength occur earlier than lower body strength. This has been attributed to the weight-bearing role of the leg muscles. It has also been suggested that boys use the upper body more than girls in their physical activities, such as climbing (De Ste Croix, 2007).

Davies (1990) tried to determine whether gender differences could be explained by lean arm mass and verified that when grip strength was expressed relative to lean forearm mass no gender differences were found. This indicates that strength is greatly related to muscle mass.

2.3.4 Exploring the world

Newborns can only perceive a limited part of the world. The process that broadens the perceptual capacity, based upon a set of biological changes that are essentially driven by maturation, is called perceptual learning. As all learning processes, it involves repetitive exposure to stimulation, and an active organism that operates in an environment.

It is well known that organisms that have the chance to develop in enriched environments develop better and precocious perceptual-motor skills. Therefore, stimulation is essential for a correct development. But research has also demonstrated that passive stimulation is not enough – growing organisms also demand active exploration of the world. Fortunately, children have a natural tendency to explore things, and that is, for sure, the best embedded mechanism to promote perceptual learning.

Gibson and colleagues (1987) have designed a very interesting experiment to elucidate the process of extracting physical properties of ground surfaces in young children. Experiments were conducted with crawling and recently walking infants on a platform with two different surfaces (rigid and safe against a soft and "squishy" surface). The perception of crossing the surface was significantly different from one condition to another, and exploration strategies were different, not only according to the surface's nature but also according to crawling-walking experience (Gibson & Pick, 2000). The more bizarre the surface, the more the children needed to explore it. In a second experiment, the two surfaces were placed side by side, offering two options to the child. Younger children showed no preference between options, but "walkers" didn't hesitate – they chose the rigid and safe surface by a large majority. This experiment shows that safer solutions are naturally adopted by older and more skilled children, emphasizing the main role of experience in the adoption of safer behaviours. Parents and caregivers that adopt extra-protective behaviours must be aware that they are also inhibiting the accurate perception of risk.

The role of self-produced movement in guided locomotion was first elucidated by the Held and Hein (1963) experiment. When comparing active versus passive kittens in the avoidance of a cliff, the results were very convincing: active experience is absolutely necessary to detect environmental affordances and to promote safe behaviour. Kittens that were reared in a passive exploration of the visual world didn't achieve an adequate behaviour in the presence of a dangerous situation. In what concerns the essential features of biological development we must keep in mind that human infants are not structurally different from other mammals.

In early stages of development, well before the tremendous development of symbolic thinking and language, it is by movement that the exploration of things can occur. That line of reasoning has been slowly incorporated into the western educational basis, and transferred into to educational principles. To a lesser extent, families have perceived that exploring is essential, and that exploring involves risk.

It is also important to remark that movement encouragement at early stages of development promotes greater confidence in the activities, even though pure motor performance may not be clearly enhanced.

2.3.5 The world is full of constraints

At every moment, children's behaviour arises from the interaction between personal characteristics (individual constraints), social and physical characteristics of the environment (environmental constraints), and the action to be performed (task constraints). If any constraints belonging to one of these three categories change, the resulting movement will change (Newell, 1986).

From a child security perspective, the analysis of the different interacting constraints is of fundamental importance. For example: a change in an individual constraint, such as an increase in height might allow the child to reach objects that were previously unreachable; a change in an environmental constraint, such as change from sunny weather to rain, will make the task of walking across a tile floor, previously dry but now wet, more difficult; and a change in a task constraint such as descending a slope with a steeper inclination might make the descent more difficult, probably causing, in some situations, a switch from a walking to a sliding position. Therefore, to provide a safe environment for the children, we need a good knowledge of the interacting constraints for different situations, since an apparent minor change in a given constraint might lead to an increased risky situation for the child.

In order to prevent childhood injuries we should act upon the interacting constraints. Active prevention strategies are intended to modify the child's behaviour in order to reduce injury risk but they might not be too effective at younger ages. On the other hand, passive strategies focus on modifying the environment (e.g., diminishing the space between rails in a barrier, so that children cannot pass through it, or avoid barriers with horizontal bars, in order to make the task more difficult). Passive strategies seem to be more efficient at younger ages. However, environmental modifications might lead sometimes to risk compensation (i.e., increased risk taking in response to environmental modifications that reduce risk). This behaviour has been demonstrated in children (e.g., Morrongiello, Walpole, & Lasenby, 2007) and in parents, who allow children to engage in greater risk taking when wearing safety gear or when environmental modifications reduce risk (Morrongiello & Major, 2002). Thus, to achieve the maximum benefits from environmental strategies there should be also individual strategies for injury prevention. For instance, even if a balcony has a protection barrier parents should teach their kids not to play there by themselves, and should never neglect their level of supervision. As Morrongiello (2005) pointed out not all environments can be modified to reduce risk, and not all behaviours are easily amenable to modification. Hence, both kinds of strategies should be viewed as complementary and equally important to the prevention of childhood injuries.

It is quite clear that a part of the "random" nature of children's accidents is the changing nature of constraints during infancy and childhood and the rate of change over time. There are good reasons to suppose that probability of accidents increases in periods of fast body changes or in early stages of motor acquisitions. It becomes clear that risk behaviour must be individually defined, and it relates to subjects' characteristics as well as environmental specific demands. According to the ecological approach the individual guides his activity by perceiving affordances, so he must be capable of perceiving the relationship between environmental properties and the properties of his own action system.

2.3.6 Perceiving action limits

As we previously mentioned babies have constrained action possibilities. For instance, they are moved by others before they can move by their own means, but they have full access to visual and auditory information. The information that they pick up from their environment supports the extraction of invariants, i.e., the common things that are perceived in the presence of a repeated event. Individual experience, of course, generates the detection of what can be done with an object or within a specific situation (Gibson, 1969).

During development children learn how to cope with the existing affordances, such as the ability of passing over surfaces due to their properties and negotiable paths, as their own body's proportions, strength and capacity for balance are changing (Gibson & Pick, 2000).

In the process of perceiving affordances children often try to gain experience by pushing the limits of their capabilities. Inefficient or dangerous behaviours usually occur when people, especially children are close to their action boundaries (Barreiros & Silva, 1995). When a wall is too high it inhibits jumping; when it is low enough, jumping is promoted; but in the boundary zone there is an increased uncertainty that might lead to unsafe behaviour. The precise delimitation of affordances in this unsafe boundary area requires specific experience on specific environmental constraints. At this point a new paradox emerges: children may experience dangerous behaviour because they have no experience but the acquisition of experience seems to be a dangerous process.

Many studies have shown that falling accidents are more frequent between 2 and 6 years of age, and this roughly corresponds to a period of experimentation and development of the perception of action limits. Balconies, windows, and stairs represent nearly 50 % of fall related injuries, while falling from trees, play equipments and other "educational" structures represent less than 10 % of related episodes (Kim, Wang, Griffith, Summers & Levy, 2000). When the opportunity for perceiving environmental affordances is restricted, and the competence for the detection of action limits is poor, accidents seem to occur mainly in non-play context.

2.3.7 Risk and risk-taking

From a child safety point of view we consider that risk is related to the probability of accident occurrence and to the severity of a possible accident. If the frequency of accidents that occur in a context is much greater than in other contexts, or if the severity of the accidents that might occur is too serious, even if their probability of occurrence is small, we consider it to be a risky context.

In order to evaluate the risk of a given situation we need to know the interacting constraints in that situation. An unfenced swimming pool, for example, constitutes a situation of a greater risk to a toddler than to an adult that knows how to swim and that can avoid risky behaviours close to the water.

We would like to emphasize that *a safe environment is not the same as a risk free environment*. Not only because that's difficult to achieve, but also because we believe there are positive developmental outcomes associated with risk-taking. The overwhelming emphasis on injury prevention in the current literature has neglected this positive aspect of risk-taking. However, exploration, challenges and risk-taking have an important role on children's development since they provide valuable opportunities for learning, problem-solving and developing social competence. As Greenfield (2004) pointed out: "In today's society there appears to be an aversion to risk; yet, without risk-taking we do not reach our potential" (p.1). As a matter of fact, parental and society apprehension concerning child safety is resulting in an increasingly overprotecting style of parenting and aversion to risk, where possible dangers are exaggerated and safety and caution are strongly promoted. This attitude might result in the avoidance of many worthwhile risks that contribute to child development. On the other hand, the removal of all potential hazards may inadvertently lead to inappropriate risk-taking, since children can seek challenging and stimulating experiences to overcome boredom and lack of stimulation (Little, 2006).

During the process of discovering what the world has to offer the infant sometimes engages in risky situations. In terms of child safety it would be important to determine not only how the child perceives the existing affordances in risky environments, but also how the adult evaluates what is a risky environment for that child, since in the early years the environments the child moves in are controlled and managed by adults.

2.3.8 Adults and supervision

Parental supervision has been considered an essential element in children's safety. Lapses in appropriate supervision have been identified as a factor across a range of childhood injuries (Morrongiello, 2005; Saluja, Brenner, Morrongiello, Haynie, Rivera, & Cheng, 2004). Peterson, Ewigman and Kivlahan (1993) stated that there is no substitute in most risky situations for developmentally appropriate parental supervision of young children. However, to define adequate supervision we must consider a variety of constraints, such as the age of the child, the hazards present in the environment and the type of injury to which the child is most susceptible. For example, an adequate supervision of a 5-month-old baby in a swimming pool implies touch and continuous attention, while intermittent attention from a distant location might be adequate supervision for 5-year-old playing in a safe environment.

Caregiver behaviours should also be considered within a larger context, as proposed by Saluja et al. (2004) in their conceptual model for caregiver decisions about injury prevention strategies. According to theses authors, risk perception is dependent on the characteristics of the caregiver, the child, and the environment.

Prevention of childhood injuries has led to a debate concerning the relative merits of focusing on modifying the environment *versus* adaptive behaviour to reduce injury risk. Researchers have tried to devise ways to decrease the necessity for supervision by pursuing different kinds of interventions to reduce environmental hazards (e.g., stair safety barriers, swimming pool fences, safety plugs or bicycle helmets). However, as long as the child depends on the caregiver to shut the stair safety barrier or the swimming pool fence, to put the safety plug on the electrical outlet, or to remind them to wear the bicycle helmet, the study of caregiver behaviour will remain of fundamental importance.

2.3.9 Falling: a review

Falls represent an important cause of injury and death. Estimates for the US indicate that three million children require emergency department care for fall-related injuries of all kinds annually (AAP, 2001). Falling impact accidents may be of very different kinds: from a simple traumatic experience with no physical consequences up to death. Statistics show that some factors are related with higher incidence of falls. These factors will be presented in the next sections.

2.3.9.1 Causes

Falls do not distribute homogeneously throughout the year, as they are prevalent in the summer, nor along the day – falls happen mainly in the afternoon. Presumably because in the summer windows tend to be open, and in the afternoon children tend to be at home. One study (Istre, McCoy, Stowe, Davies, Zane, Anderson, & Wiebe, 2003) refers that in Dallas spring and autumn seasons have a higher incidence of falls than summer, because the heat of summer in Dallas led to an almost universal use of air conditioning, with windows kept closed. They also reported a peak of falls around meal times when supervision might be more careless. These results show that some context-related variables influence the risk of falling, and that includes air temperature, daily routines and other factors.

Falls do not occur equally in both sexes (boys fall more frequently than girls – 50 to 300 % more, according to different reports), and they don't have the same impact in children of different ages. More than 2/3 of all falls occurred in children younger than 5 years of age (Sieben, Leavitt, & French, 1971) and higher mortality rates can be observed at younger ages. In US statistics, ethnicity effects were also observed, probably reflecting life conditions and poverty.

Age seems to be related to the nature of falls, including the places from which children fall. Kindergarten children usually fall from windows, and older boys fall from dangerous areas, such as rooftops and fire escapes (AAP, 2001; Sieben, Leavitt, & French, 1971). This seems to be consistent with the development of judgemental capabilities, since preschoolers don't seem to perceive increased danger at higher elevations, and older children may become less careless when they are playing.
Istre and colleagues (2003) analysed falls from balconies and windows and concluded that for more than two thirds of balcony related falls, the children fell from between the balcony rails, all of which were spaced more than 10 cm apart. Amazingly, more than two thirds of window related falls, occurred in windows lower than 61 cm.

Epidemiologic data rarely refers to the design of the barriers involved in the accidents, and there is no reliable information about detailed characteristics of protection devices. Press clips (see Appendix 2) are more focused on the supervision details about the accident (Was the mother present? Was the kid alone? Was he/she playing under adequate supervision? Was it the first accident? And so on and so forth). No serious analytical information was found in press clips that offered or supported a scientific approach to this matter.

Different studies report some predisposing factors for fall injuries, such as: a history of previous major unintentional injury to the patient or siblings, neurologic disorders, developmental delay or hyperactivity, and documented parental neglect. Families with social and demographic factors such as: poverty, single parent households, inadequate child care, deteriorating housing, overcrowding, family instability, and acute stress factors such as recent moves, illnesses and job changes, seem to be more prompt to this type of accidents (AAP, 2001; Sieben, Leavitt, & French, 1971; Spiegel & Lindaman, 1977; Mayer, Meuli, Lips, & Frey, 2006; Crawley, 1996; Pressley & Barlow, 2007).

Falls happen for a lot a reasons but the association with some consistent causes deserve special attention: family related variables, novelty and variation in daily routines, physical constraints, children's characteristics, and adequate supervision.

Information about the risk of drowning, on the other hand, showed that infants are most likely to drown in bathtubs, toddlers in swimming pools, and other children in other freshwater sites (National Institute of Child Health and Human Development, 2001). It is quite clear that the prevention of drowning is closely connected to the devices that limit access to the water, and that in the case of toddlers the nature and structure of restraining devices must be carefully analyzed. The risk of drowning in bathtubs was also analyzed in the present report, leading to the introduction of barriers that simulated bathtubs height. The main risk in this case was not the risk of falling but the risk of drowning.

2.3.9.2 Consequences

Data from the US Safe Kids Campaign (in AAP, 2001) indicated that falls can account for 9 million treatments in emergency units that do not require hospitalization. Despite these numbers and the fact that falls are the leading cause of injury in children, they are rarely fatal in children. Falls from a second floor or higher (more than 6.7 m) and falls into hard surfaces may lead to death. Many fatalities occur in falls from around 10 m, while falls from first and second floor, although non-fatal, may provoke serious injuries. Falling from balconies and windows are a part of these accidents.

The AAP (2001) has analysed data from the CPSC (US Consumer Product Safety Commission) relative to children who fell from windows in 1993. These data indicate that around 90% of all falls derive from falls of less than 7 m. Nearly 50% of these accidents were classified as "serious" such as fractures, intracranial haemorrhages and internal lesions. The most frequent injuries were head injuries followed by fractures of the extremities (Mayer et al., 2006; Istre et al., 2003; Lallier, Bouchard, St-Vil, Dupont, & Tucci, 1999; Wang, Kim, Griffith, Summers, McComb, Levy & Mahour, 2001; Vish, Powell, Wiltsek, & Sheehan, 2005). Children between 1 and 3 years of age may fall from all storeys. Older children (4-6 yr) fall from smaller heights. This trend may be explained by the fact that younger children cannot fully evaluate the impact of falling from different heights. Older children, on the other hand, can discriminate depth and height more accurately, and, accordingly, they can also anticipate negative impacts of falling from higher places. Risky behaviours in more dangerous conditions are less likely to occur.

In general, falling from greater heights lead to more severe injuries. However, the nature of the surface onto which the child falls and the degree to which the fall is broken on the way down modify the pattern and severity of injuries (Sieben, Leavitt, & French, 1971; AAP, 2001). Even though the potential for serious injury is superior as the height increases, the number of injuries from low-height falls is much greater, presumably due to much larger exposure to this type of danger and perhaps because of poorer precautions (Culvenor, 2002).

The costs of injuries from falls are considerable. Nonfatal injuries in children result in lost time in school, emotional distress and possibly in a lifetime of impaired function and expensive care. Several authors have calculated the economic impact of falls. Total costs are usually very high because they must include emergency room diagnoses and treatment, after-care, rehabilitation (Spiegel and Lindaman, 1977). Falls have also some impact in academic achievement, well-being and social activity.

In Los Angeles County, the annual hospital charges from 1986 to 1988 were more than $600 000, or about $5000 per child admitted with fall-related injury (AAP, 2001). Data from the US (National Hospital Ambulatory Medical Care Survey) for 1992-1994 revealed a national cost of $958 million for emergency care for children who were seen for falls. Although fewer than 3% were falls from extreme heights, they would still account for almost $10 million annually, including 26% paid by Medicaid (AAP, 2001).

The fatal injuries have costs that are not possible to determine, since the loss of a child's potential productivity and creativity has a profound impact on society (Crawley, 1996).

From 1990 to 2000, drowning was the second leading cause of unintentional injury death in the USA, from 1 to 19 years of age (American Academy of Pediatrics, 2003). The AAP recommendations concerning this topic are quite clear: installation of fencing that isolates the swimming pool from the house and yard is effective in preventing more than 50 % of swimming pool drowning among young children. They also mention that no protection device can replace adequate supervision. However, the characteristics and dimensions of such fences were beyond the scope of the report. The present investigation is concerned with the restraining effects of barriers in very young infants from a morphological and behavioural perspective.

3. METHODS

3.1 Participants

Ninety eight children from 9 to 75 months divided by 3 age groups: group 1 (10 children from 9-18 months), group 2 (30 children from 19-36 months) and group 3 (58 children from 37-75 months of age). Sample differences between groups reflect the relevance of the barrier crossing problem at different ages, and that makes the third group the most interesting for the purpose of this study, therefore the bigger one.

3.2 Barriers description

Children of different ages also behave differently. Accordingly, obstacles have to be specified in a distinct way in the three groups, and for each age group different types of barriers were selected (see Table 3).

A total of 13 barriers were tested, following recommendations and standards. Some barriers were not recommended by available norms but seemed adjusted to very young children. Finally, some barriers with standard dimensions and with the upper barriers rotative and backed (i.e., located inwards in relation to the rest of the profile) were analysed.

Table 3. Description of the barriers selected for the different age groups.

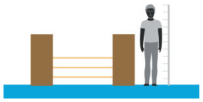
Barrier	Age (months)	Height (cm)	Characteristics	Drawing (reference child 1,10m tall)	Picture
A-1	9-18	39	3 horizontal cylinder bars with gaps of 11 cm between them and a diameter of 2 cm. The purpose of selecting this type of barrier for this age group was mainly to see if children would try to go through the gaps.		
B-1	9-18	30	Vertical wood panel of 30 cm, 2 cm thick, round soft edge at the top. The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing above the barrier.		
C-1 D-2	9-18 19-36	50	Vertical wood panel of 50 cm, 2 cm thick, round soft edge at the top. The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing above the barrier. Children who can cross a barrier this high can get into most bathtubs by themselves. This barrier was included in groups 1 and 2 so that we could analyse the capability of climbing into a bathtub on a developmental perspective.		 

Table 3. Description of the barriers selected for the different age groups (cont.).

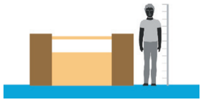
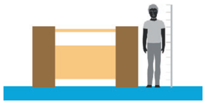
Barrier	Age (months)	Height (cm)	Characteristics	Drawing (reference child 1,10m tall)	Picture
E-2	19-36	67	Vertical wood panel of 45 cm + 18 cm gap + horizontal bar 4 cm high x 2 cm thick. The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing through or above the barrier. The gap of 18 cm from a height of 45 cm was selected based on regulations from France (NF P 01-012:1988, currently under revision) adopted by Portugal in 2005 as a voluntary technical specification.		
F-2	19-36	78	11 cm gap + vertical wood panel of 45 cm + 18 cm gap + horizontal bar 4 cm high x 2 cm thick. The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing through or above the barrier. The barrier is similar to barrier E-2 but the 18 cm gap is from a height of 56 cm.		

Table 3. Description of the barriers selected for the different age groups (cont.).

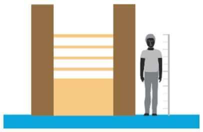
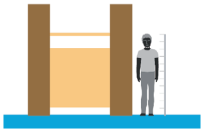
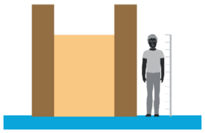
Barrier	Age (months)	Height (cm)	Characteristics	Drawing (reference child 1,10m tall)	Picture
G-3	37-75	110	Vertical wood panel of 50 cm + 4 horizontal bars, 4 cm high x 2 cm thick, with gaps of 11 cm between them. The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing above the barrier. This type of barrier is used in many balconies in different countries.		
H-3	37-75	113	11 cm gap + vertical wood panel of 80 cm + 18 cm gap + horizontal bar 4 cm high x 2 cm thick. The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing through or above the barrier. This type of barrier with no horizontal bars was expected to increase time to cross.		
I-3	37-75	110	Vertical wood panel of 110 cm, 2 cm thick, round soft edge at the top. The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing above the barrier. 110 cm is the most frequent height required for guards on balconies and swimming pool barriers.		

Table 3. Description of the barriers selected for the different age groups (cont.).

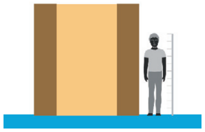
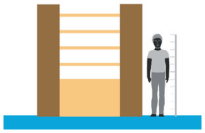
Barrier	Age (months)	Height (cm)	Characteristics	Drawing (reference child 1,10m tall)	Picture
J-3	37-75	150	Wood panel of 150 cm, 2 cm thick, round soft edge at the top. The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing above the barrier. 150 cm is the highest standard recommendation for swimming pool fences.		
K-3	37-75	138	Vertical wood panel of 50 cm + 4 horizontal bars, 4 cm high x 2 cm thick, with gaps of 18 cm between them. The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing through or above the barrier. This barrier is similar to barrier G3 but with greater gaps between the horizontal bars. This gap is according to NF P 01-012:1988 (France) and was adopted by Portugal in 2005 as a voluntary technical specification.		

Table 3. Description of the barriers selected for the different age groups (cont.).

Barrier	Age (months)	Height (cm)	Characteristics	Drawing (reference child 1,10m tall)	Picture
L-3	37-75	110	Vertical wood panel of 60 cm + 4 horizontal bars, 4 cm high x 2 cm thick, with the first gap of 8 cm and the other gaps of 5,5 cm + a cylinder rotating rod, with a diameter of 3,5 cm, backing 8,5 cm from the barrier, with a vertical distance of 6 cm and a gap of 10,4 cm from the last bar). The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing above the barrier despite of the backing rod.		
M-3	37-75	110	Vertical wood panel of 100 cm + a cylinder rotating rod, with a diameter of 3,5 cm, backing 8,5 cm from the barrier, with a vertical distance of 6,5 cm and a gap of 10,7 cm from the panel. The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing above the barrier despite of the backing rod. This barrier should be more difficult to transpose than the previous one because it has no footholds.		

Table 3. Description of the barriers selected for the different age groups (cont.).

Barrier	Age (months)	Height (cm)	Characteristics	Drawing (reference child 1,10m tall)	Picture
N-3	37-75	110	Vertical wood panel of 100 cm + 2 cylinder rotating rods, with a diameter of 3,5 cm, the first one backing 8,5 cm from the barrier, and the second one backing 6,5 cm from the first one, with a vertical distance of 6,5 cm and a gap of 9,19 cm. The purpose of selecting this type of barrier for this age group was to see if children would succeed in passing above the barrier despite of the 2 backing rods. This barrier should be more difficult to cross than the previous one due to the second rod.		

3.3 Anthropometric variables selection

The variables that were chosen to characterize the children's morphology (Table 4) were those that literature underlines as having the greatest influence upon their capacities in these kinds of skills: 1) reaching objects put at a high level and/or climbing barriers (maximum vertical reaching height, upper limb length which means acromiale-radiale length, lower limb length that means trochanterion height and stature), 2) to pass between two obstacles (head circumference, biparietal breadth and anterior-posterior chest breadth), 3) grasping objects and moving the body over the obstacles (hand length which means midstylion-dactylion lenght), strength (handgrip), and body mass (weight).

Table 4 - Anthropometric variables.

Objective	Selected variables
Reaching/ Scaling	Maximum Vertical Reaching Height
	Acromiale-Dactylion Length
	Trochanterion Height
	Stature
Passing Through	Head Circumference
	Biparietal Breadth
	A-P Chest Breadth
Grasping, strength and body mass	Midstylion-Dactylion Length
	Handgrip
	Weight

3.4 Variables description

The anthropometric measures were obtained according to ISAK (2006), with two exceptions - the maximum vertical reaching height and the biparietal breadth, and included: stature, weight, head circumference (HC), biparietal breadth (BB), anterior-posterior chest breadth (APCB), midstylion-dactylion length (MDL), acromiale-dactylion length (ADL), trochanterion height (TH) and maximum vertical reaching height (MVRH).

Figure 2 presents the protocol used to measure the different anthropometric variables selected.

Stature: the child assumes a standing position with the arms hanging by the sides backing the anthropometer, bare-footed with the heels together and the feet extremities separated approximately 60º. Weight must be equally distributed on both feet and the head placed in the Frankfurt plan, which means that the horizontal plan passes through the tragion point (the notch superior to the tragus of the ear) and through the orbitale point (lower edge of the eye socket). At the moment of the measurement the child must adopt an erect position and must inhale deeply (Fig. 2).

Weight: The child, bare-footed and with light clothes, is put on the centre of the weighing scale with his weight well distributed on both feet and looking forward assuming a relaxed standing position with the arms hanging by the sides (Fig. 2).

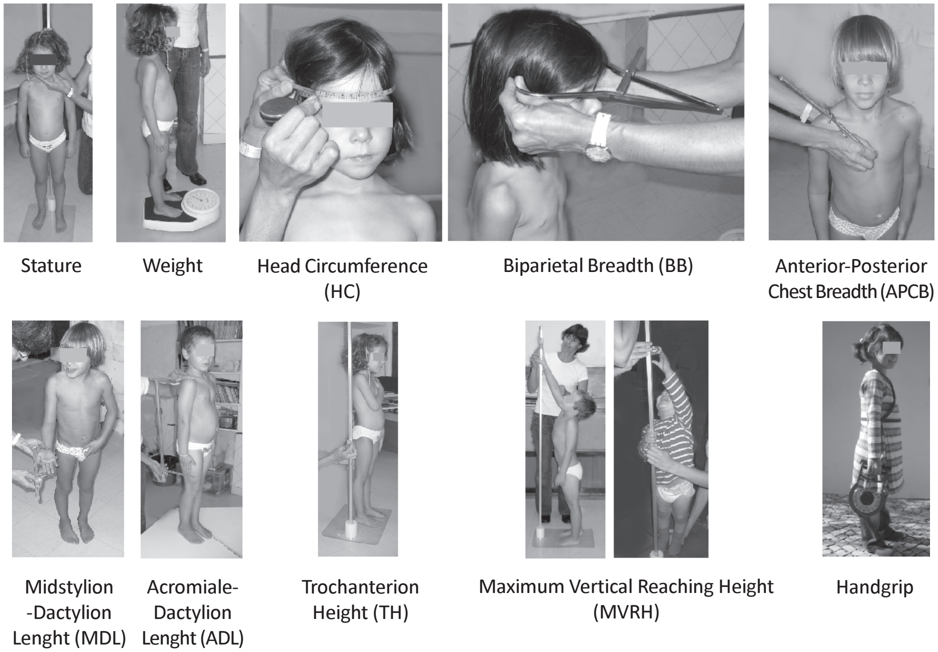


Figure 2 – Anthropometric variables.

Head Circumference (HC): The child assumes a relaxed standing position with the arms hanging by the sides and the head in the Frankfurt plan. The measure is taken perpendicularly to the head longitudinal axis, in the horizontal plan, immediately over the glabella (mid-point between the brow ridges) (Fig. 2).

Biparietal Breadth (BB): The child assumes a relaxed standing position with the arms hanging by the sides and the head in the Frankfurt plan. The measure is taken perpendicularly to the head longitudinal axis, between the most lateral portions of parietal bones (Fig. 2).

Anterior-Posterior Chest Breadth (APCB): The child assumes a relaxed standing position, with the arms hanging by the sides. The measure is taken at end-tidal expiration and obtained between mesoesternale point (point located on the corpus sterni at the level of articulation of the 4^{th} chondrosternal articulation) and the spinous process of the vertebra located at the same level on a plan parallel to the floor, and on the biggest posterior projection point (Fig. 2).

Midstylion-Dactylion Lenght (MDL) – Hand Length: The child assumes a relaxed standing position with the left arm hanging by the side. The right elbow must be slightly flexed, forearm supinated and the fingers extended (but not in hyper-extension). The measure is taken in parallel with the hand´s longitudinal axis between midstylion point (medial point of an imaginary horizontal line localized on the anterior area of the wrist at the level of the stylion, which means the most distal point of the lateral margin of the styloid process of the radius) and the dactylion point (the tip of the middle finger) (Fig. 2).

Acromiale-Dactylion Lenght (ADL) - Upper Extremity Length: The child assumes a relaxed standing position, with the arms hanging by the sides having the hand with its fingers together. One branch of the calliper is held on the acromiale point (the most superior aspect of the most lateral part of the acromion border), while the other branch is placed on the dactylion point (Fig. 2).

Trochanterion Height (TH) - Lower Extremity Length: The child assumes a standing position with his left upper limb along the trunk and the right upper limb flexed over the chest, with the feet together and the weight equally distributed on both feet. The measure is taken from the most superior trochanterion point to the floor (Fig. 2).

Maximum Vertical Reaching Height (MVRH) - The child assumes a standing position, barefooted facing the anthropometer as close as possible. The child must raise his dominant upper limb extended with his hand opened with the fingers together, pushing up, as far as possible, without raising the heels from the floor (Fig. 2).

Handgrip: The child assumes a standing position and takes the dynamometer in the preferred hand. He must squeeze it forcefully (gradually and continuously), at least 2 seconds, holding the dynamometer away from the body. During the test, the arm and hand holding the dynamometer should not touch the body. The instrument is held in line with the forearm and hangs down at the side. The child repeats the test with the non preferred hand (Fig. 2).

The measurement instruments used were a scale – Seca model 761 7019009 from Vogel & Halke (Germany), to determine body mass; an anthropometer from Siber-Hegner GPM (Zurich) to obtain stature and trochanterion height, a large sliding caliper from Siber-Hegner GPM (Zurich) to take lengths (acromiale-dactylion and hand) and breadths (biparietal and A-P chest), an anthropometric tape from Rosscraft to measure the head circumference and a grip strength dynamometer T.K.K. 5001 GRIP A from Takei Scientific Instruments CO, LTD.

3.5 Standard and reference norms

Most part of the published reference norms appear in the ambit of population nutritional status assessment using for this reason, a restrict number of anthropometric measures, particularly the head circumference, recumbent length, standing height, weight, body mass index, waist circumference, mid-arm circumferences, upper arm length, subscapular skinfold thickness, triceps skinfold thickness, maximal calf circumference, upper leg length, mid-thigh circumference. This fact makes the comparison difficult of some of our collected data with the existent norms. In this study we used as comparison terms a national reference norm - RAPIL (Vieira & Fragoso, in press) and three international reference norms - WHO, Euro-Growth 2000 (Haschke, van't Hof & Euro Study Group, 2000) and NHANES 1999-2002 (McDowell, Fryar, Hirsch & Ogden, 2005).

Appendix 3 presents tables with the reference norm values for the percentiles 5, 10, 50, 90 and 95, relatively to each studied variable and for ages between 12 months and 6 years, and the values of mean (M), standard deviation (SD), maximum (MAX) and minimum (MIN) presented by the children in our sample.

3.5.1 Comparison between our children's morphology and the morphology of the children of the reference populations

Being aware that the number of assessed children for each age group is limited and that all the comparisons between our results and the reference populations' are influenced by the individual characteristics of the children of our sample, we still consider the importance of the comparison between our children's morphology and the morphology of the children of the reference populations in order to allow some generalization for the European population.

In what concerns stature we can say that until 3 years the children of our study are generally taller than WHO and Euro Studies; however they are smaller than NHANES. From 4 to 6 years the children in our sample are taller than those averaged in RAPIL.

Considering weight we can declare that our children are in general and for every age heavier than any of the used reference populations. This information must be carefully understood: a number of variables that are closely connected to body weight were not considered.

The head circumferences of the children that we have measured are, for all ages, bigger than WHO children, except for 3 year-old girls, being that the head circumferences are bigger than the children of both sexes of the Euro Study at 2 and 3 years only for girls.

Between 4 and 6 years the upper limbs length (acromial-dactylion lenght) of our children was superior to the RAPIL children, which reflects the bigger stature shown by these children. The comparison concerning the lower limbs (trochanterion height) was not possible because we have used different methods. In RAPIL lower limb length was obtain indirectly through the difference between stature and sitting height, and in our study it was assessed from the trochanterion point to the floor.

Although at the age of 4 years the children of our study have superior thoracic breadth (anterior-posterior chest breadth) when compared with the children of RAPIL, at 5 years of age thoracic breadths are identical in both studies. Regarding this variable, at 6 years the girls of our study have smaller dimensions than those reported in RAPIL, being the boys' dimensions similar for both populations.

In short, the children we have assessed are generally taller and heavier, have longer limbs, larger head circumferences and bigger thoracic breadths than the children of the reference populations we used for comparisons. One of the reasons for the existence of these differences can be explained by the normal tendency of children to present a bigger growth of the linear dimensions (stature and length) and the earlier accumulation of fat mass which has repercussions on weight increase. Bigger children can be favoured in what concerns passing over a barrier, but cannot slide through barriers as easily.

3.6 Task description

Wearing comfortable clothes, children were asked to climb the different types of barriers selected for their age group. The experimental part of the project was developed in the summer and early autumn, and some kids performed the task barefoot. No indications about that detail were given by the experimenters, so children could use or take off their shoes.

Instructions and encouragement was provided by a member of the experimental team, by the day care teacher, or by one of the parents (in the younger group). Most children were filmed in their day care centre, with their teachers/ educators nearby, in order to reduce the impact of a non-familiar environment. Informed consent was obtained from the children's parents previous to the study and institutions were fully informed about the nature and purpose of the study.

In groups 1 and 2, different toys were placed on the opposite side of the barrier in order to catch children's attention. Limit time to pass a barrier was 300 s. Children who couldn't cross the barrier after 300 s were allowed to go to the other side and play with the toys for a brief period in order to keep them motivated for the next barrier.

After 150 s, in groups 1 and 2, the experimenter placed 2 boxes (dimensions 30 cm length x 20 cm width x 10 cm height, and 30 cm length x 20 cm width x 20 cm height) close to the barrier, offering additional but not compulsory aid to cross the barrier. In group 3 the children knew that the boxes were available and could get them whenever they wanted.

The children were taken to the experiment apparatus in small groups. The task was performed by one child at a time. Visual access to other children's trials was allowed.

In all conditions the children were filmed from behind. The video recordings were pasted into movie fragments for analysis. The following items were then considered: 1) success/failure in crossing the barrier (with or without boxes), 2) time to cross the barrier (from the moment of the first contact with the barrier, previous to the climbing action, until contact with the floor on the other side, or until the last visible frame when contact was occluded by the height of the barrier), and 3) passing technique (action modes adopted for crossing).

3.7 Actions modes

The action modes adopted for the crossing of the barrier were classified following the criteria of action control and safety when crossing the barrier. It was assumed that when crossing a barrier with maximum control, children keep their vertical posture, keeping the head above the waist. Arms can move easily and balance when crossing the barrier is not greatly affected. The risk of falling is minimal (see Fig. 3). The second action mode is generally used when the level of difficulty of the barrier restrains the amount of options. In these situations vertical balance is sacrificed in favour of a position that offers a greater contact between the body and the barrier. So, the barrier is crossed with the head and waist at the same level. This technique is more dangerous and guarantees less balance than the previous one (see Fig. 4). The third action mode is the most dangerous one since it is characterized by crossing with the head under the waist. In a way this represents a situation of a probable fall (see Fig. 5). Next, we present some examples of the action modes described.

1 – HOW – Head over waist – the child crosses the barrier with the head higher than the waist (see Fig. 3). This technique demonstrates a better movement control.

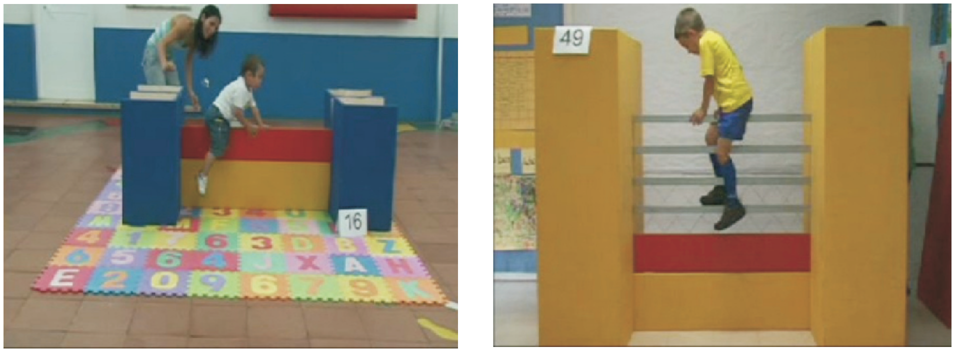


Figure 3 - Action mode 1 (HOW – Head over waist).

2 – HAW – Head and waist - the child crosses the barrier with the head and the waist at the same level (see Fig. 4). Fear and need for safety are evident.

Figure 4 - Action mode 2 (HAW – Head and waist).

3 – HUW – Head under waist - the child crosses the barrier with the head lower than the waist (see Fig. 5). This technique implies a higher risk of head impact and probably expresses a minor control of movement.

Figure 5 - Action mode 3 (HUW – Head under waist).

Sometimes the child exhibited more than one action mode to cross a barrier (e.g., started with head over waist but when the second leg crossed the barrier the head and waist were at the same level). This and other possible mixed action types were registered and classified as "mixed techniques". The 3 main action modes and a mixed one are described in Figure 6, where the whole action sequence may be observed.

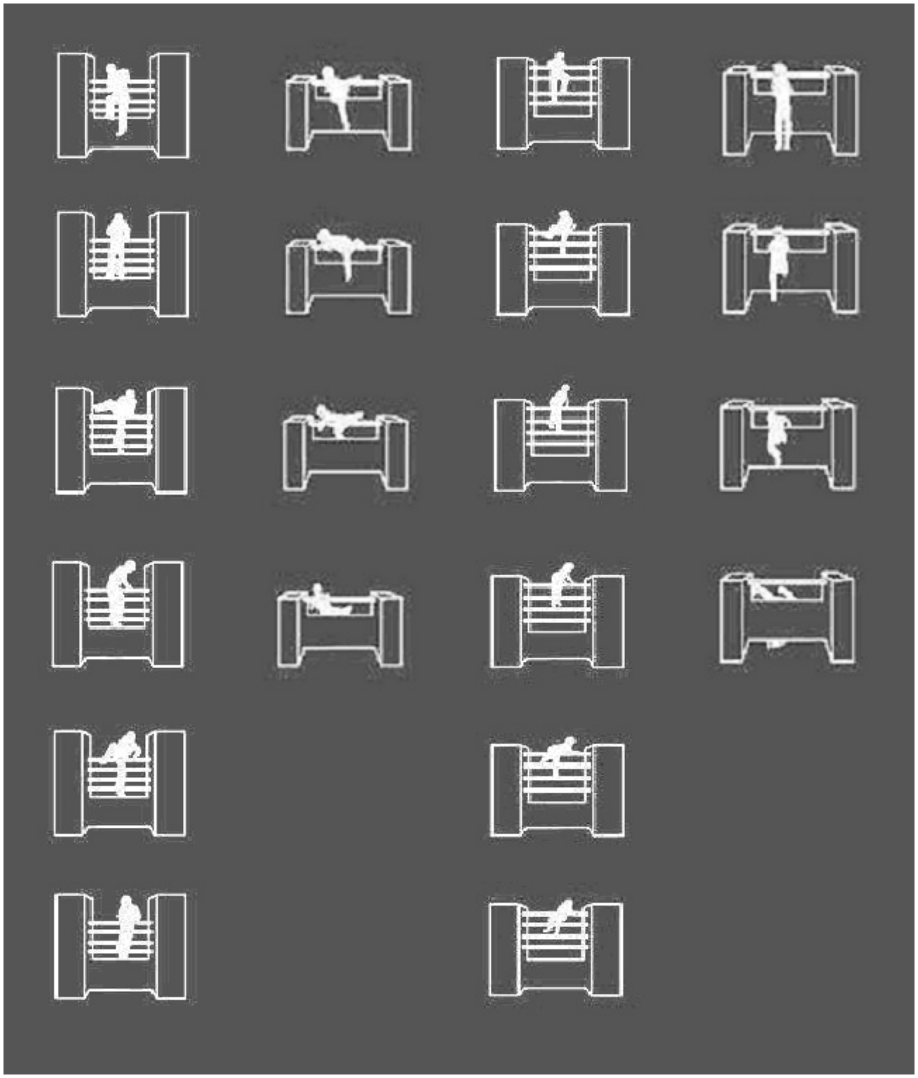


Figure 6 – Sequences of action modes. HOW (left column), HAW (left-center column), HOW to HAW (right-center column), and HUW (right column).

4. RESULTS

4.1 Crossing different barriers: success rate

One of the ways to assess the degree of difficulty is the percentage of success in crossing a barrier.

The crossing of each barrier was tested under 2 different conditions: 1) without any environmental help or 2) with the help of the boxes children could climb into.

The analysis of the frequencies and percentage of success and failure (with no help and with boxes) while crossing different barriers is presented in Appendix 4.

As expected, the percentage of success was different in the 3 age groups. As age increases children seemed to be more skilful in this sort of tasks. In the younger group, 2 barriers could totally prevent crossing and the less complex barrier showed a success rate of only 20% (see figure 7). However, this data should be carefully analysed due to the reduced size of the sample in group 1. In group 2, the most difficult barrier could prevent crossing in 90% of the cases; in the less complex barrier 70% of all children exhibited some sort of crossing technique (see figure 8). In the older group the more complex barrier allowed crossing for one third of the sample; however the less complex barrier presented a success percentage of 95% (see figure 9), that is, almost everyone could pass it.

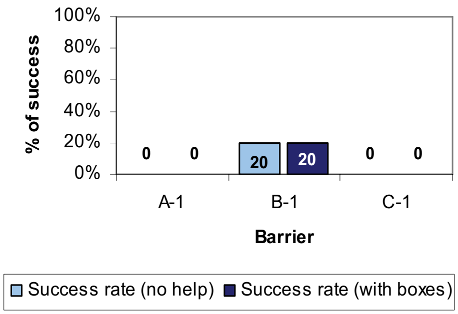


Figure 7 - Percentage of success in crossing the 3 barriers in Group 1.

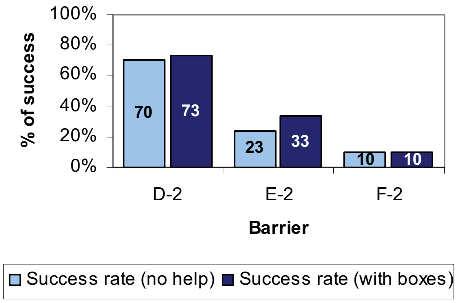


Figure 8 - Percentage of success in crossing the 3 barriers in Group 2.

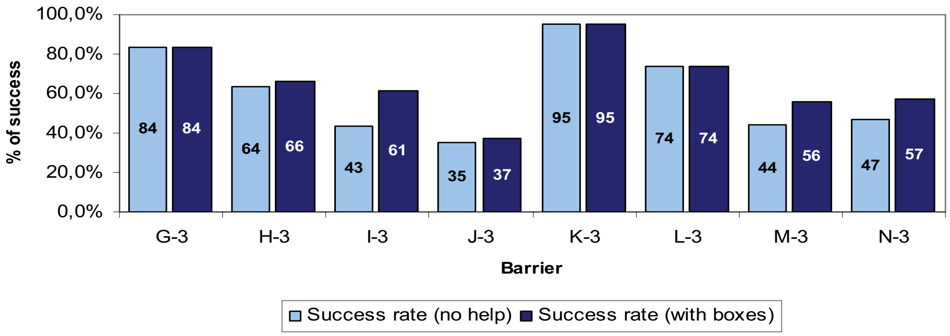


Figure 9 - Percentage of success in crossing the 8 barriers in Group 3.

By analysing the success rate in the different barriers we can verify that the boxes were used mainly in the barriers that had no footholds (e.g., I-3, M-3, N-3) when children perceived that by using the boxes they would have an advantage. In barrier J-3 (1,50 m panel) the boxes didn't seem to bring any advantages since, even with boxes, most children wouldn't be able to reach the top of the barrier. This is probably why most children didn't use the boxes in that situation. When the barriers are easy to climb (e.g., G-3, K-3, L-3) the children don't need to get the boxes to help the action of crossing. In terms of child safety, we can conclude that parents and caregivers should pay special attention to small climbable objects that can be placed near barriers, specially if the barriers are more difficult to climb. When the barriers are easy to climb the surveillance must be strengthened but the children will not need to have any extra help to climb them if they want to. Boxes, chairs, other pieces of furniture, or even friends can act as action encouragement devices or enablers (see Fig. 10).

Figure 10 – Friends can encourage and help to cross a barrier.

In order to evaluate barrier resilience by age group we have grouped all crossings in 6 groups:

- 0 % No children in the age group crossed this barrier
- 25 % Up to 25% of the children crossed this barrier
- 50 % Between 25% and 50% of the children crossed this barrier
- 75 % Between 50% and 75% of the children crossed this barrier
- 100 % Between 75% and 99% of the children crossed this barrier
- 100 % All the children crossed this barrier.

The results of this analysis are presented in Tables 5 and 6.

Table 5 - Grouping crossings for 9-36 months. Six success levels were considered.

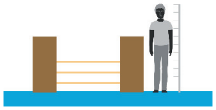
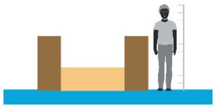
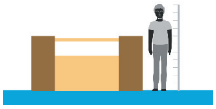
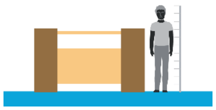
Barrier (reference child 1,10m tall)	Age (months)	Success	Barrier (reference child 1,10m tall)	Age (months)	Success
 A-1	9-18	0 %	 D-2	18-36	75 %
 B-1	9-18	25 %	 E-2	18-36	25 %
 C-1	9-18	0 %	 F-2	18-36	25 %

Table 6 - Grouping crossings for 36 months and older. Six success levels were considered.

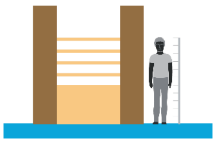
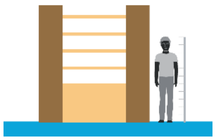
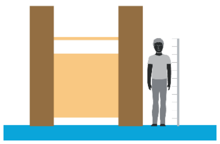
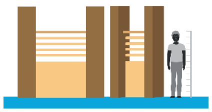
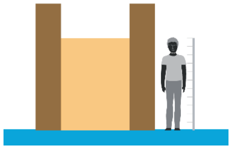
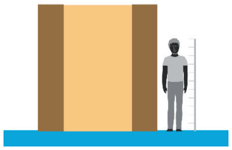
Barrier (reference child 1,10m tall)	Age (months)	Success	Barrier (reference child 1,10m tall)	Age (months)	Success
 G-3	36-48	75 %	 K-3	36-48	100 %
	48-60	50 %		48-60	100 %
	60-72	100 %		60-72	100 %
	> 72	100 %		> 72	100 %
 H-3	36-48	25 %	 L-3	36-48	50 %
	48-60	75 %		48-60	100 %
	60-72	100 %		60-72	100 %
	> 72	100 %		> 72	100 %

Table 6 - Grouping crossings for 36 months and older (cont.)

Barrier (reference child 1,10m tall)	Age (months)	Success	Barrier (reference child 1,10m tall)	Age (months)	Success
 I-3	36-48	25 %	 M-3	36-48	0 %
	48-60	25 %		48-60	50 %
	60-72	75 %		60-72	75 %
	> 72	100 %		> 72	100 %
 J-3	36-48	0 %	 N-3	36-48	25 %
	48-60	0 %		48-60	50 %
	60-72	50 %		60-72	50 %
	> 72	100 %		> 72	100 %

4.2 Crossing different barriers: measuring the time to cross

When the crossing of barriers is not prevented for all children, from a child safety point of view it's important to investigate their delaying capacity, expressed by the time needed to cross each barrier. To meet this purpose we analysed the time the best climbers took to cross different barriers and we also considered the percentage of success according to different time categories. These categories mirror different periods of lack of adult supervision that might exist, accordingly to the daily activity the adult might be involved in. Finally, we examined the correlation between time to cross and different anthropometric variables, in order to determine which variables seem to be more relevant to barrier crossing.

Table 7 - Time to cross different barriers in Group 3– best climbers. Data was ranked and the best 15 subjects in each barrier were selected for analysis.

Barrier	Time to cross of the 15 best climbers (in seconds)			
	Mean	SD	Min	Max
G-3	6,60	1,30	4	9
H-3	10,93	3,39	5	17
I-3	9,13	3,94	3	14
J-3	14,33	7,39	6	36
K-3	7,60	1,84	4	10
L-3	10,80	4,28	4	18
M-3	6,87	2,95	3	12
N-3	8,80	3,59	2	12

4.2.1. Time the best climbers take to cross different barriers

Each barrier was crossed by a different number of children (from 15 to 41 in group 3). The most difficult barriers were crossed only by the most skilful climbers but the easiest barriers were crossed by good and bad climbers. In order to avoid the influence of different skill levels, and since in terms of safety we should consider the fastest children, we selected the 15 best climbers in each barrier to analyse time to cross. This analysis refers only to group 3 since in groups 1 and 2 the number of children that crossed some barriers was too small for testing. The results are shown in Table 7.

Mean time to cross was always less than 15 seconds, and only three barriers were able to limit the action of crossing for more than 10 seconds. These values clearly reflect the idea that there are no absolute safe barriers. When considering children with a high skill level, the maximum time to cross the most demanding barrier was 36 seconds, and that subject was, for sure, an outlier.

4.2.2. Percentage of crossings according to different time categories

When children are nearby risky environments, such as stairs, balconies or swimming pools, they are usually supervised by an adult. However, since risky environments are frequently equipped with different kinds of barriers or restraining devices to avoid children's access to them, short periods of lack of attention might exist if, for example, the adult is involved in some other kind of activity. In this investigation, we selected different time categories related to different daily activities as shown in Table 8.

Table 8 - Average time needed to perform different daily activities.

Action	Drawing	Time to perform the action
Turning on the TV and switching between 3 channels to check what's on		20 seconds
Filling a 1,5 L bottle of water		30 seconds
Reading one page of a book		60 seconds
Brushing teeth		120 seconds

Of all the successful crossings in our study, 191 (77,3%) occurred in less than 20 seconds, 41 (16,6%) took less than 30 seconds and 14 (5,7%). Only one episode lasted more than 1 minute (see Fig. 11).

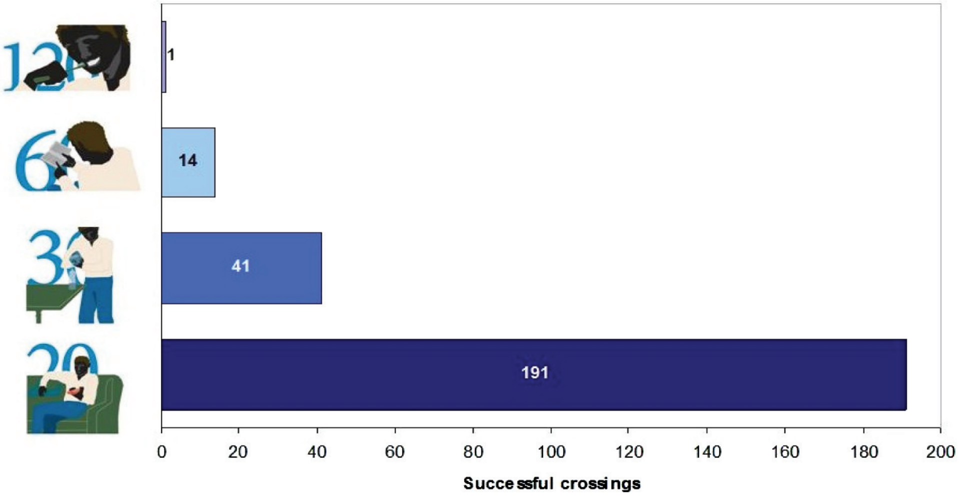


Figure 11 - Successful crossings by time category.

Subsequently, we analysed the percentage of crossings that occurred in each time category for the different barriers. This analysis was limited to groups 2 and 3 since in group 1 the number of crossings was very limited. We also excluded from analysis all the crossings that were made with the help of the boxes, since time to get the boxes or some other kind of help to cross might vary accordingly to each environment.

4.2.2.1. Percentage of crossings according to different time categories in Group 2

In group 2 most barriers were crossed in less than 20 seconds by the great majority of children (see Fig. 12). All the children that crossed the most difficult barriers in this group (i.e., barrier E-2 and barrier F-2) did so in less than 20 seconds. Barrier D-2 was crossed by a greater number of children (70% of success), so the difference in skill levels was probably greater. In this barrier a few children took more than 20 seconds to cross.

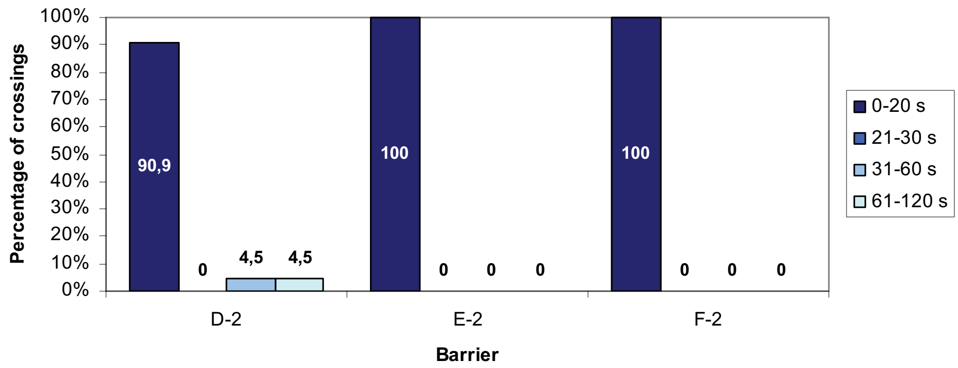


Figure 12 - Percentage of crossings according to different time categories in Group 2.

4.2.2.2. Percentage of crossings according to different time categories in Group 3

All the children that crossed the different barriers in group 3 did it in less than 1 minute, and the great majority of them did it in less than 20 seconds (see Fig. 13). Once again children that climbed the barrier with the lowest success rate in crossing (i.e., barrier J-3), seem to be the most skilled (93,3% performed the task in less than 20 seconds). On the other hand, in the easiest barrier to climb (i.e., barrier K-3 which had a success rate of 95,3%) the difference of skill levels between the climbers is more notorious, since only 63,4% of the crossings took less than 20 seconds.

In group 3, the great majority of children easily crossed all barriers. Time to cross rarely exceeds 20 seconds. Even the highest and more sophisticated barriers couldn't delay the action of crossing in such a way that allowed for parental intervention. In group 2, from 18 to 36 months, the most efficient barrier prevented crossing in 90 % of the attempts.

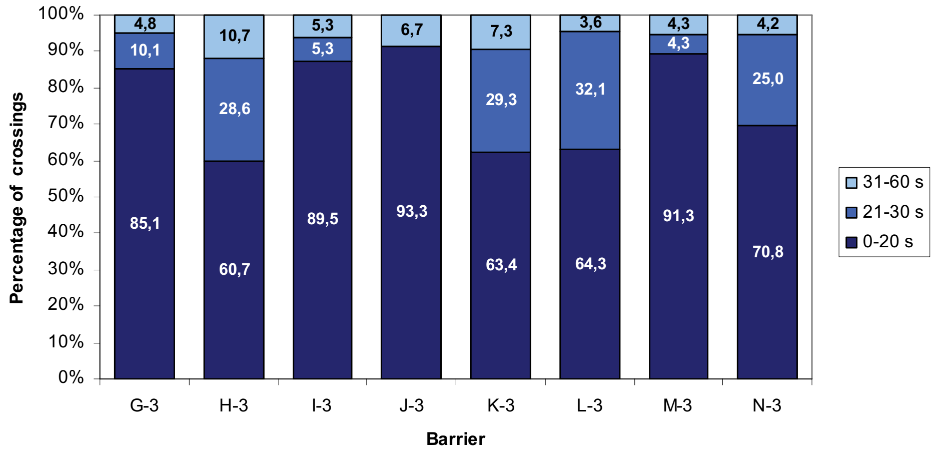


Figure 13 - Percentage of crossings according to different time categories in Group 3.

4.3 Influence of morphological variables

In order to determine the influence of morphological variables in the action of crossing the barriers we analysed: i) the relationship between these variables and success in crossing, ii) the relationship between these variables and time to cross.

4.3.1 Relationship between morphological variables and success in crossing different barriers

The comparison between the morphological characteristics of the group of children that crossed each barrier versus the group that couldn't cross was only performed when both groups had at least 20 % of the total sample. For this reason, we excluded from analysis barriers F-2 (which only 10% of the children were able to cross), and G-3 and K-3 (which, respectively, only 16,3% and 4,7% of the children were not able to cross). We also excluded group 1 from analysis due to the small success rate in that group.

Data relative to the comparison of different morphological characteristics in children that failed versus children that succeeded in the action of crossing each barrier are shown in Tables 9 to 16. Table 17 summarizes the significant differences found for the barriers analysed in group 3.

Table 9 - Influence of morphological characteristics in crossing barrier D-2 (* p<0.05).

Variable	Failure		Success		DF	T	U	p
	M	SD	M	SD				
Age	2,21	,41	2,39	,33	28	-1,30	-	,203
Stature	85,07	5,73	89,37	4,68	24	-1,88	-	,073
Weight	13,33	2,01	13,82	1,92	24	-,535	-	,598
BMI	18,37	1,58	17,24	1,31	24	1,76	-	,091
ADL	34,58	3,05	37,29	2,29	-	-	25,50	**,016***
TH	38,12	3,33	41,37	3,30	-	-	25,50	**,036***
MVRH	99,75	8,66	104,52	7,92	24	-1,27		,217
HC	48,62	,87	48,70	2,27	-	-	40,00	,222
BB	13,30	,49	12,83	,50	24	2,05	-	,052
APCB	11,77	,73	11,67	,68	24	,299	-	,767
MDL	9,83	,73	10,36	,63	24	-1,73	-	,097

Table 10 - Influence of morphological characteristics in crossing barrier E-2 (* p<0.05).

Variable	Failure		Success		DF	T	U	p
	M	SD	M	SD				
Age	2,26	,36	2,60	,22	28	-1,30	-	**,025***
Stature	87,82	5,22	89,87	5,07	-	-	47,50	,272
Weight	13,71	1,69	13,69	2,56	24	-,535	-	,977
BMI	17,75	1,24	16,83	1,80	24	1,76	-	,149
ADL	36,42	2,83	37,33	2,30	-	-	53,00	,435
TH	40,15	3,55	41,87	3,38	24	-2,11	-	,279
MVRH	102,34	8,54	106,34	6,80	-	-	45,50	,225
HC	49,00	,87	47,81	3,68	-	-	66,00	,977
BB	13,04	,50	12,66	,55	24	2,05	-	,106
APCB	11,78	,62	11,44	,83	24	,299	-	,256
MDL	10,14	,67	10,51	,69	24	-1,73	-	,217

Table 11 - Influence of morphological characteristics in crossing barrier H-3 (* p<0.05).

Variable	Failure		Success		DF	T	U	p
	M	SD	M	SD				
Age	4,41	,74	5,32	,75	-	-	86,50	**,001***
Stature	105,26	6,21	112,78	7,67	42	-3,34	-	**,002***
Weight	16,91	2,73	20,63	3,89	-	-	90,50	**,001***
BMI	15,19	1,36	16,09	1,48	42	-1,99	-	,053
ADL	44,25	3,03	48,06	3,48	42	-3,65	-	**,001***
TH	51,51	3,90	56,03	4,69	42	-3,26	-	**,002***
MVRH	129,97	8,73	141,14	9,82	42	-3,77	-	**,000***
HC	50,54	1,36	51,20	1,97	42	-1,69	-	,098
BB	13,66	,65	13,84	,54	42	-,957	-	,344
APCB	12,46	,70	12,76	,65	42	-1,44	-	,157
MDL	11,61	,80	12,59	,88	42	-3,65	-	**,001***
Strength	6,08	2,86	9,31	3,22	42	-3,24	-	**,002***

Table 12 - Influence of morphological characteristics in crossing barrier I-3 (* p<0.05).

Variable	Failure		Success		DF	T	U	p
	M	SD	M	SD				
Age	4,52	,73	5,60	,61	-	-	60,00	**,000***
Stature	106,40	6,11	114,83	7,73	42	-4,04	-	**,000***
Weight	17,65	2,95	21,42	4,08	42	-3,56	-	**,001***
BMI	15,50	1,52	16,10	1,41	42	-1,33	-	,191
ADL	44,75	2,93	49,20	3,28	42	-4,74	-	**,000***
TH	52,18	3,86	57,29	4,66	42	-3,99	-	**,000***
MVRH	131,68	8,57	144,18	9,33	42	-4,62	-	**,000***
HC	50,75	1,25	51,24	1,30	42	-1,25	-	,218
BB	13,75	,56	13,81	,61	42	-,323	-	,749
APCB	12,51	,69	12,85	,62	42	-1,68	-	,100
MDL	11,79	,83	12,82	,84	42	-4,05	-	**,000***
Strength	6,41	2,52	10,50	3,12	42	-4,70	-	**,000***

Table 13 - Influence of morphological characteristics in crossing barrier J-3 (* p<0.05).

Variable	Failure		Success		DF	T	U	p
	M	SD	M	SD				
Age	4,54	,75	5,77	,35	40,64	-7,31	-	**,000***
Stature	106,21	6,14	117,26	6,16	41	-5,61	-	**,000***
Weight	17,60	2,91	22,60	3,59	-	-	52,00	**,000***
BMI	15,51	1,44	16,36	1,41	-	-	149,50	,123
ADL	44,87	3,01	50,07	2,74	41	-5,56	-	**,000***
TH	51,97	3,86	58,75	3,53	41	-5,65	-	**,000***
MVRH	131,73	8,58	147,07	7,23	41	-5,89	-	**,000***
HC	50,79	1,34	51,41	1,02	41	-1,54	-	,130
BB	13,75	,59	13,79	,58	41	-,215	-	,831
APCB	12,51	,66	13,01	,55	41	-2,51	-	**,016***
MDL	11,79	,78	13,10	,69	41	-5,42	-	**,000***
Strength	6,58	2,72	11,07	2,69	-	-	41,50	**,000***

Table 14 - Influence of morphological characteristics in crossing barrier L-3.

Variable	Failure		Success		DF	T	U	p
	M	SD	M	SD				
Age	4,64	,77	5,04	,72	36	-1,48	-	,147
Stature	107,03	5,74	110,95	7,68	36	-1,47	-	,151
Weight	17,65	3,01	19,73	3,53	36	-1,65	-	,107
BMI	15,32	1,59	15,90	1,13	36	-1,24	-	,222
ADL	45,02	3,16	47,20	3,35	36	-1,79	-	,082
TH	52,34	4,01	54,73	4,66	36	-1,44	-	,159
MVRH	132,48	8,75	138,23	9,57	36	-1,67	-	,105
HC	50,89	1,45	51,06	1,26	36	-,345	-	,732
BB	13,65	,65	13,77	,60	36	-,521	-	,605
APCB	12,47	,90	12,77	,62	12,16	-,938	-	,345
MDL	11,92	,69	12,38	,83	36	-1,54	-	,131
Strength	7,14	2,46	9,16	3,40	-	-	84,50	,176

Table 15 - Influence of morphological characteristics in crossing barrier M-3 (* p<0.05).

Variable	Failure		Success		DF	T	U	p
	M	SD	M	SD				
Age	4,68	,74	5,53	,48	-	-	122,00	**,000***
Stature	108,61	9,37	115,00	6,79	-	-	166,00	**,002***
Weight	18,08	3,10	21,25	3,67	-	-	176,00	**,004***
BMI	15,31	1,72	15,96	1,37	-	-	288,00	,402
ADL	45,43	3,11	49,59	2,90	50	-4,93	-	**,000***
TH	52,56	3,87	57,50	3,90	50	-4,56	-	**,000***
MVRH	133,21	8,78	144,43	8,02	50	-4,75	-	**,000***
HC	50,94	1,59	51,28	1,09	49,07	-,894	-	,376
BB	13,69	,62	13,86	,56	50	-,982	-	,331
APCB	12,57	,70	12,93	,63	50	-1,92	-	,061
MDL	11,97	,83	12,84	,77	50	-3,90	-	**,000***
Strength	7,17	2,76	10,01	3,01	-	-	147,50	**,002***

Table 16 - Influence of morphological characteristics in crossing barrier N-3 (* p<0.05).

Variable	Failure		Success		DF	T	U	p
	M	SD	M	SD				
Age	4,78	,74	5,34	,69	-	-	185,00	**,009***
Stature	108,97	9,45	114,33	7,52	-	-	183,00	**,008***
Weight	18,07	3,00	21,20	3,76	-	-	170,00	**,004***
BMI	15,22	1,74	16,10	1,29	-	-	243,00	,126
ADL	45,47	3,06	49,34	3,24	49	-4,38	-	**,000***
TH	52,83	3,91	56,81	4,49	49	-3,38	-	**,001***
MVRH	133,26	8,69	143,75	8,90	49	-4,26	-	**,000***
HC	50,93	1,52	51,36	1,17	49	-1,13	-	,265
BB	13,69	,61	13,83	,59	49	-,835	-	,408
APCB	12,59	,71	12,93	,60	-		221,50	**,053***
MDL	11,91	,79	12,88	,75	49	-4,50	-	**,000***
Strength	7,02	2,64	10,12	2,99	49	-3,86	-	**,000***

Table 17 - Morphological variables – comparisons between children that can and that cannot cross different barriers (* p<0.05).

Variable	Barrier H-3	Barrier I-3	Barrier J-3	Barrier L-3	Barrier M-3	Barrier N-3
Age	**,001***	**,000***	**,000***	,147	**,000***	**,009***
Stature	**,002***	**,000***	**,000***	,151	**,002***	**,008***
Weight	**,001***	**,001***	**,000***	,107	**,004***	**,004***
BMI	,053	,191	,123	,222	,402	,126
ADL	**,001***	**,000***	**,000***	,082	**,000***	**,000***
TH	**,002***	**,000***	**,000***	,159	**,000***	**,001***
MVRH	**,000***	**,000***	**,000***	,105	**,000***	**,000***
HC	,098	,218	,130	,732	,376	,265
BB	,344	,749	,831	,605	,331	,408
APCB	,157	,100	**,016***	,345	,061	**,053***
MDL	**,001***	**,000***	**,000***	,131	**,000***	**,000***
Strength	**,002***	**,000***	**,000***	,176	**,002***	**,000***

Age, stature, weight, ADL, TH, MVRH, MDL and Strength seem to be determinant for the action of crossing in most barriers. Success in crossing Barrier L-3, the first one presented with the cylinder rotating backing rod, doesn't seem to be related to any of the studied variables. This particular task may involve two components: an easy one, that is just climbing a natural bars structure, and a hard one, that is passing over a rotating bar backing from the barrier. As a new complex task it may involve cognitive processing (how to deal with a rotating bar) and morphology may have little influence. Performance in this kind of tasks may well be of a cognitive nature rather than of a motor one.

The influence of anthropometric variables is quite clear in Fig. 14 where we can see as the relationship between stature and barrier's total height varies among children, conditioning the effort each child has to make to reach the top of the barrier.

Figure 14 – Three children with different relationships between stature and total height of barrier J-3.

4.3.2 Relationship between morphological variables and time to cross different barriers

Some individual characteristics of the children, such as age, body dimensions and strength, influence their ability to climb. It would be expected that older, taller and stronger children took less time to cross most barriers than younger, shorter and weaker children. In order to verify this assumption, we analysed the correlations between those characteristics and time to cross different barriers (see Table 18).

Table 18 - Correlations between time to cross different barriers and anthropometric variables (* p<0.05).

	Time G-3	Time H-3	Time I-3	Time J-3	Time K-3	Time L-3	Time M-3	Time N-3
Age	**-,349***	-,261	**-,522***	,215	**-,537***	**-,502***	-,324	-,309
Stature	-,289	**-,374***	**-,537***	,091	**-,496***	**-,516***	**-,610***	**-,497***
Weight	-,312	-,295	-,397	,154	**-,376***	**-,472***	**-,603***	**-,417***
BMI	-,235	-,048	-,085	,154	,059	-,152	-,375	-,102
ADL	-,296	**-,438***	**-,590***	-,086	**-,486***	**-,581***	**-,565***	**-,527***
TH	-,280	**-,393***	**-,477***	,129	**-,492***	**-,524***	**-,497***	**-,527***
MVRH	-,304	**-,399***	**-,598***	-,063	**-,538***	**-,610***	**-,613***	**-,529***
HC	,008	-,371	**-,477***	-,043	-,162	-,342	-,251	-,035
BB	,040	-,123	-,411	-,047	-,101	-,349	,082	-,201
APCB	-,067	**-,478***	-,286	-,008	-,040	-,219	**-,465***	-,160
MDL	**-,398**	**-,439***	**-,540***	-,441	**-,452***	**-,483***	**-,623***	-,382
Strength	-,265	**-,438***	-,465	,185	**-,517***	**-,532***	**-,592***	-,367

As we can see from the analysis of table 18, time to cross most barriers is inversely correlated with: age, stature, ADL, TH, MVRH, MDL and strength. So, we can conclude that, in general, as children grow older and stronger, with bigger stature, bigger arms, legs and hands, and a bigger maximum vertical reaching height, their time to cross most barriers decreases. Barriers G-3 and I-3 seem to be exceptions to this rule. Barrier G-3 was the first one presented to the children. Age seemed to be determinant for the time to cross since older children took less time to cross, however, most body dimensions were not relevant in that barrier, probably due to its easily climbable design (with horizontal bars). In barrier J-3 no variable seemed to be determinant for the time needed to cross. J-3 was the most difficult barrier to cross, the few children who could cross it were tall and strong enough to jump and hold on to the top (1,50 m), pull themselves up using their arms and throwing one leg over the edge of the horizontal support to pass to the other side. Anthropometric characteristics of these children were probably very similar and none of those characteristics seems to have influenced time to cross. An alternative explanation is that the difficulty level of the J-3 barrier may cause the climbing skills of children to be more influential than their anthropometric characteristics in regards to the time in which they cross.

The relationship between strength and weight (relative strength) was investigated (see Fig. 15).

The strength/weight ratio seems to be an important indicator of climbing competence, since the ability to move over a barrier involves the capacity of supporting body weight for long periods and the power to elevate trunk and legs using arms. Great increments were observed until 5 years of age, followed by a relative conservation of this ratio. This trend may indicate that older children are more predictable, while younger children can rapidly develop new and unpredictable climbing skills.

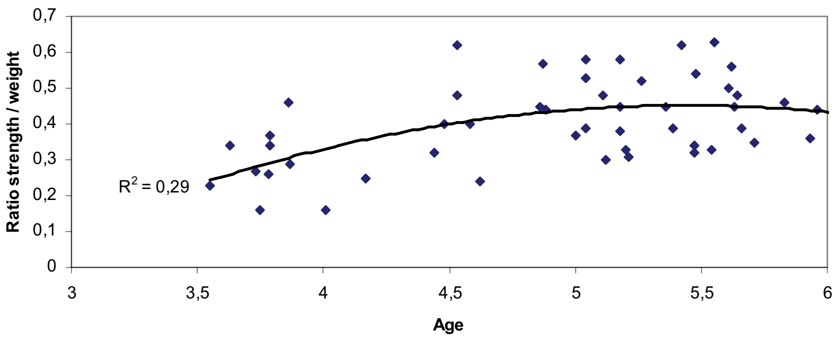


Figure 15 – Relationship between age and ratio strength/weight in group 3.

As we can see, it's clearly easier for older children to elevate their own bodies, since the ratio strength/weight increases as age progresses. As a matter of fact, around 30% of the relationship between strength and weight is explained by age (R^2=0,29).

To better illustrate these differences we divided group 3 in 3 age subgroups (mean ages of 4,11 years, 5,18 years and 5,83 years) (Fig. 16). As we can see, the ratio strength/weight increases from 0,34 in the youngest subgroup to 0,45 in the eldest one, making the task of lifting the body over an object a much easier one.

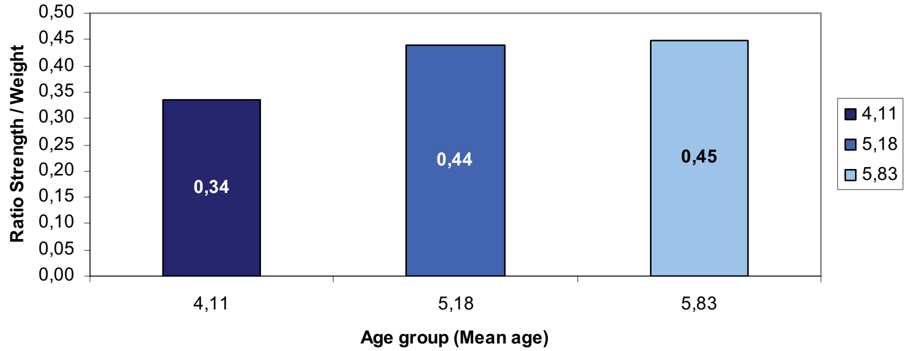


Figure 16 – Ratio strength/weight in 3 age subgroups of Group 3.

To better comprehend the influence of morphological variables on time to cross different barriers we selected the 15 best climbers for each barrier in Group 3 and performed a linear regression stepwise, entering as independent variables the ones we identified as relevant for the action of crossing in most barriers (i.e., age, stature, weight, ACL, TH, MVRH, MDL and strength). In Barriers H-3, J-3, K-3, L-3 and M-3 no significant predictors of time to cross were found. The results for the other barriers are shown in Table 19.

Table 19 - Predictors of time to cross for barriers G-3, I-3 and N-3.

Barrier	Predictors	R Square
G-3	Strength	,444
I-3	MVRH / ADL	,751
N-3	MVRH	,394

4.4 Selected comparisons between barriers

In order to determine the influence of different barrier characteristics in time to cross, we have compared 7 pairs of barriers as shown in Table 20. We selected barriers with similar general characteristics, that were tested in group 3 and that were possible to be compared.

Table 20 - Influence of different barrier characteristics in success and time to cross (Wilcoxon Signed Ranks Test / Paired Samples Test).

Barriers compared		Short description		Characteristic to be compared	% of success in crossing		Time to cross Mean (SD)		Z	T	p
1st B	2nd B	1st B	2nd B		1st B	2nd B	1st B	2nd B			
I-3	J-3	110 cm solid panel	150 cm solid panel	Height	43,2	34,9	10,60 (5,58)	14,33 (7,39)	-2,35	–	,019
G-3	I-3	110 cm barrier with footholds (horizontal bars)	110 cm solid panel	Existence of footholds	83,7	43,2	8,42 (4,89)	11,74 (7,09)	-2,12	–	,034
G-3	L-3	110 cm barrier with footholds (horizontal bars) all in the same plane	110 cm barrier with footholds (horizontal bars) + a cylinder rotating rod backing from the panel	Existence of a cylinder rotating rod in a different plane in barriers with footholds	83,7	73,7	10,77 (6,02)	15,45 (7,82)	-2,99	–	,003
I-3	M-3	110 cm solid panel	110 cm barrier with a 100 cm solid panel + 1 cylinder rotating rod backing from the panel	Existence of a cylinder rotating rod in a different plane in barriers without footholds	43,2	44,2	10,47 (5,67)	9,33 (7,95)	-1,16	–	,244
I-3	N-3	110 cm solid panel	110 cm barrier with a 100 cm solid panel + 2 cylinder rotating rods backing from the panel	Existence of 2 cylinder rotating rods in a different plane in barriers without footholds	43,2	47,2	11,19 (7,00)	13,56 (9,81)	-,483		,629
M-3	N-3	110 cm barrier with a 100 cm solid panel + 1 cylinder rotating rod backing from the panel	110 cm barrier with a 100 cm solid panel + 2 cylinder rotating rods backing from the panel	Existence of one more cylinder rotating rod in a different plane in barriers without footholds	44,2	47,2	9,70 (5,53)	12,20 (7,22)	–	-2,56	,019
L-3	M-3	110 cm barrier with footholds + 1 cylinder rotating rod backing from the panel	110 cm barrier with a 100 cm solid panel + 1 cylinder rotating rod backing from the panel	Existence of footholds in barriers with a cylinder rotating rod in a different plane	73,7	44,2	11,71 (5,09)	11,93 (8,33)	–	-,093	,928

Accordingly to the results shown in Table 20, we can state that:

- A *greater height* (i.e., from 110 cm to 150 cm) reduces the percentage of success in crossing (43,2% to 34,9%) and significantly delays time to cross (Z=-2,35, p=,019);
- The *non existence of footholds* in a 110 cm barrier reduces the percentage of success in crossing (83,7% to 43,2%) and significantly delays time to cross (Z=-2.12, p=.034);
- The existence of a *cylinder rotating rod in a different plane in a 110 cm barrier with footholds* reduces the percentage of success in crossing (83,7% to 73,7%) and significantly delays time to cross (Z=-2.99, p=.003);
- The existence of a *cylinder rotating rod in a different plane in a 110 cm barrier without footholds* increases the percentage of success in crossing (43,2% to 44,2%) and doesn't significantly delay time to cross (Z=-1.16, p=.244);
- The existence of *2 cylinder rotating rods in a different plane in a 110 cm barrier without footholds* increases the percentage of success in crossing (43,2% to 47,2%) and doesn't significantly delay time to cross (Z=-.483, p=.629);
- The existence of *2 cylinder rotating rods in a different plane*, instead of 1, increases the percentage of success in crossing (44,2% to 47,2%) but significantly delays time to cross (t(19)=-2.56, p=.019);
- The *absence of footholds in barriers with a cylinder rotating rod in a different plane* reduces the percentage of success in crossing (73,7% to 44,2%) but doesn't significantly influence time to cross (t(13)=-.093, p=.928).

4.5 Action modes used to cross different barriers

Most children crossed the barriers with their head over the waist (i.e., action mode HOW) (see Fig.17). This seems to be the preferred mode when the barrier characteristics and the child's skill level allow this kind of crossing. However, barriers with crossable gaps (e.g., barrier E-2 and F-2) seem to promote different kinds of crossing, since it's easier to pass between the gap with head and waist at the same level (i.e., HAW) or with the head under the waist (HUW). These are dangerous crossing techniques, because they limit the control of balance and movement. The selection of the action mode HOW is much more frequent in the older group, indicating better motor control. Children in the younger group might still be testing other ways to cross barriers, even though they may look unsafe behaviours. In this study children didn't try to pass below the barriers that had a lower gap.

There is not enough anecdotal evidence to detect action modes concerning feet-first approaches. This topic claims for further ecological research. However, this type of approaches are probably more frequent in balconies were children can sit with the legs hanging to the outside. This type of situation was not acceptable in this study, since any situation that may involve danger or ethical conditioning is strictly forbidden by research norms for studies with young individuals. The potential risk of such testing condition under minimal ecological validation do not recommend this type of experimental setup.

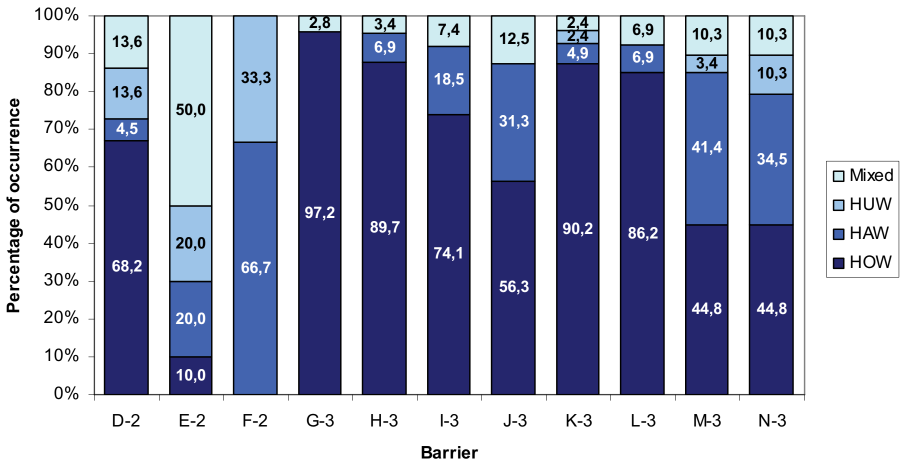


Figure 17 - Percentage of occurrence of the different action modes in barriers of Group 2 and Group 3.

5. CONCLUSION

The final discussion will be structured in a Frequently Asked Questions mode. We believe that this structure will better serve the purposes of this report. First, we will ask some broad and general questions and later we will try to frame some of the findings of this study in the form of simple answers.

Is it possible to develop absolutely safe barriers?

No. As in prison escapes, methods may be of opportunistic or planned nature. When a child sees an opportunity to escape there is a reasonable probability that it may happen, even though he/she had never thought about that. On the other hand, looking around and planning the best way to solve a problem reflects advanced cognitive skills that emerge in later stages of childhood. The perfect awareness of action consequences comes with aging, and for that reason, unpredictable behaviours of very young children are very common. Statistics related with falling accidents in children clearly evidenced that the nature of the falls changes with age. Barriers may be, when properly used, a good help in controlling and preventing accidents and a reasonable solution for behaviour management, as they create temporary negative affordances in the environment.

Can parents and caregivers rely on barriers to prevent access to dangerous places or falling accidents?

No. Physical barriers are just a part of a trilogy that also involves education and supervision. Barriers and other safety devices cannot substitute full supervision and education. The main effect of a barrier is the creation of additional time to do something and, in some conditions, the severe limitation of movements and actions. But, as all literature about children's developments has remarked, human infants enjoy hard challenges, and what better challenge for children than a hard-to-cross barrier?

As biological entities, children do not have full awareness of right and wrong. The perception and categorization of things and behaviours as good and bad requires an adequate and continuous set of demonstrations, instructions, and knowledge. That is part of the educational business, and it cannot be expected to develop spontaneously. Adequate supervision is the third element. Children must not be left alone, but that is inevitable for short moments even with most protective parents. Our data suggests that even a little moment can offer the opportunity to cross a barrier. Parents and caregivers must be aware of that, and strategies to control and reinforce supervision must be developed. Barriers alone are just time delaying devices, not absolute preventive tools. They can make things difficult for a child and give the opportunity to adult intervention. News clips and descriptive information shows that lack of adequate supervision is a major determinant of this kind of accidents.

Do children seek environmental help to cross barriers?

Yes, if necessary. Older children tend to seek environmental help more often than younger children. When barriers were easy to climb children didn't use the boxes. They were used mainly in the barriers that had no footholds and when children perceived that they would be helpful. In the most difficult barrier children didn't use the boxes since they wouldn't be able to reach the top of the barrier anyway. We can say that the boxes acted as action encouragement devices.

Parents and caregivers should pay special attention to possible action enablers, such as boxes, chairs or other pieces of furniture that can be used by children to have access to places they weren't supposed to.

Are there non crossable barriers?

No. In general all barriers are crossable. However, in our study we verified that in children till 18 months 2 barriers could not be crossed.

A greater height reduces the percentage of success in crossing. The most difficult barrier to cross in group 3 (37 to 75 months) was J-3, the 150 cm panel (most demanding standard worldwide for swimming pools).

Barriers with footholds are easier to cross than panel barriers of the same height. Footholds can transform a safe barrier into a dangerous one.

In barriers with footholds, the existence of a cylinder rotating rod in a different plane (i.e., inwards) makes crossing more difficult. However, in panel barriers, the existence of a cylinder rotating rod in a different plane facilitates climbing and increases the percentage of success. That percentage was even higher for barriers with 2 cylinder rotating rods in a different plane, probably because they offered additional support surfaces.

Do barriers delay children's access to dangerous places?

Yes, some more than others. Height (from 110 cm to 150 cm) significantly delays time to cross. Barriers with footholds take less time to be crossed than panel barriers of the same height.

In barriers with footholds, the existence of a cylinder rotating rod in a different plane (inwards) delays crossing. However, in panel barriers, the existence of one or two cylinder rotating rods in a different plane does not significantly delay crossing.

In barriers with a cylinder rotating rod in a different plane, time to cross wasn't significantly different between panel barriers and barriers with footholds.

However, none of the tested barriers could assure a significantly protective delay. Best climbers can cross a difficult barrier in just a few seconds. Children must be aware of the consequences of actions and that is not a physical, physiological or mechanical problem. That is an educational problem.

Which children's characteristics influence their ability to cross barriers?

Age and variables related to reaching / scaling and to grasping, strength and body mass (stature, MVRH, ADL, TH, MDL, weight and strength) seem to be determinant for crossing in most barriers. On the other hand, time to cross most barriers is inversely correlated with age and variables related to reaching / scaling and to grasping and strength (stature, ADL, TH, MVRH, MDL and strength).

It is clear that the morphology and movement related aspects clearly influence the ability to cross barriers. The ratio strength/weight indicates the amount of effort children have to do to lift their bodies over a barrier. This ratio increases as age progresses - in our sample nearly 30% of the relationship between strength and weight was explained by age. Although major changes occur in younger kids, the development of this ratio indicates that it's clearly easier for the older children to elevate their own bodies to cross barriers.

We can conclude that, in general, as children grow older and stronger, with bigger stature, bigger arms, legs and hands, and a bigger maximum vertical reaching height, their ability to cross barriers increases while the time to do that is decreasing.

In some barriers anthropometric characteristics are strong predictors of time to cross. For example, in barrier I-3 (110 cm panel), maximum vertical reaching height and upper - extremity lenght can account for 75% of the differences in time to cross.

Is there any relevant information about children's morphology that should be considered when designing safety barriers?

Yes, several aspects:

- three-year-old children can reach the top of a barrier at 110 cm, since mean value for maximum vertical reaching height was 116 cm. At the age of six, they can reach a barrier of 150 cm. A little jump of 10 cm height will give access to 150 cm barriers at the age of five. We have observed that some children were capable of climbing the highest (150 cm) barrier (nearly one third in the older group) and they can do it in less than 20 seconds.

- barriers with a maximum height of 90 cm allow four-year-old children to look over it but they do not offer the perfect conditions concerning depth perception. Stature in different populations, at this age, may vary from 96 up to 107 cm. At the age of six many children can easily look over a 110 cm barrier, a common reference for barriers.

- values of lower extremity lenght indicate that a child can easily move one foot into a foothold or move a whole leg over an obstacle located at 40 cm (at the age of two), 50 cm (at the age of four), and 60 cm (at the age of six). Strength increase in combination with these morphological changes transform children into very efficient climbers.

- the gap between bars (vertical or horizontal) must be inferior to 10 cm, but the exact value requires measurements of children as young as 6 months. Mean values of biparietal breadth and chest breadth observed in the younger group

(12 month-old) were, respectively, 12,6 and 10,4 cm, but minimum values of 10.2 cm were observed for chest breadth in a girl. Keep in mind that we've observed a very limited sample and that lower values at these ages are conceivable. One-year-old children can crawl efficiently and some months later they can walk independently, having new access to virtually everywhere. A width of 10 cm is very close to the lower limits in our sample at the age of two. This topic requires further investigation.

- the stability of barriers deserves careful attention. Mean weight values of more than 20 Kg were observed at the age of 5, but in the older group a body weight of more than 30 Kg is to be expected. Have in consideration that children move their bodies and that the impact of a moving body with more than 30 Kg is not to be ignored. Climbing a fence is a sequence of active movements of great amplitude, so fixations must be carefully examined. It is also possible that two or more children can move simultaneously over a barrier. In that case, the interaction of force vectors may originate dangerous situations.

- children can reach objects through a fence or barrier, without any participation of shoulder and thorax, at a distance of 30 cm (one-year-old) and more than 50 cm (six-year-old). These values were derived from arm length measurements in our sample. This is something that must be considered in non-solid barriers.

Is it possible to predict who can and who cannot transpose a certain barrier?

We can hardly make that prediction. It was clear that some barriers were age related, that is they can offer reasonable protection for some age ranges. Older, taller and stronger children have increased potential to transpose more difficult barriers, but we know from literature that they also have a better capacity to perceive depth and a finest detection of affordances of the environment. For that reason, older children become more predictable.

6. FINAL REMARKS / RECOMMENDATIONS

As final recommendations we would like to emphasize the following aspects:

- the design of good barriers that can delay child access to the other side has probably the same cost as the design of unsafe barriers, but safe barriers will save lives and money spent on fall related injuries.

- as there are no absolutely efficient barriers, supervision and education must be considered. Barriers are just time delaying devices.

- barriers must fit users' age and characteristics. Different ages may require different standards. If children of different ages and motor development stages are expected, the most resilient barrier must be adopted. Taking into account body dimensions and other characteristics of children of different ages, 110 cm should be considered as an acceptable minimum standard for the height of balconies and other fences.

- taller barriers offer additional protection, since they make reaching and crossing difficult with normal leg amplitude.

- horizontal bars in a barrier make it easier to climb. That seems true for bar barriers and for a combination of panel and bar barriers. The combination of panels and bars offers little additional protection.

- rotating bars in a different plane inwards at the top of the barrier may offer additional protection. The time to cross a barrier with a backed top bar that can rotate is significantly delayed. However, more children were able to cross this barrier.

- the gaps between bars, and the vertical distance from the ground to the panel or first bar, must have less than 10 cm. Thorax measurements and bi-parietal dimensions clearly support the recommendation of small gaps. This issue requires a larger sample of creeping and crawling infants to determine the exact minimum gap required.

- barriers are not just a matter of dimension: motor ability and strength play a major role in the action of cross. It seems inadequate to assume the dimension of a barrier just by taking into consideration static body dimensions.

- individual differences play a role in the time to cross a barrier. Some morphological variables can be identified, particularly those connected to linear expressions of growth.

- the stability of the barriers is a very important issue, particularly in older children. Body weight and inertial characteristics of children's movements indicate that solid fixations must be considered.

- avoid surfaces and objects that can increment the height of the children and maximum reaching distance. Children of all ages will use available objects if they can take advantage of that. Therefore they will cross higher barriers and reduce the time to cross them.

- for technical requirements purposes, a barrier that can delay access of children younger than 6 should have the following characteristics:
  Minimum of 110 cm height;
  Gaps smaller than 10 cm;
  No footholds.

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APPENDIX 1

Balconies and swimming pool fences

Climbing structures

Climbing structures

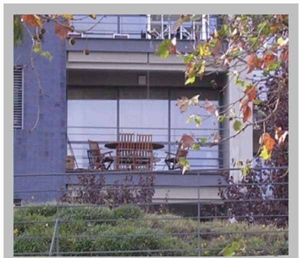
Climbing structures

Extra support for climbing

Climbing structures

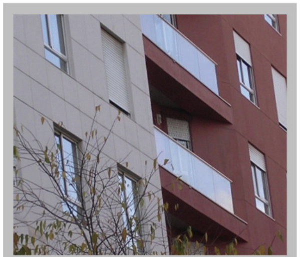
Climbing structures

Climbing structures

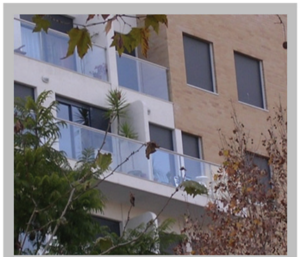


Climbing structures

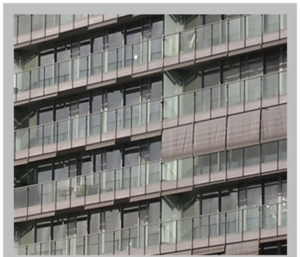
Climbing structures



Glass barrier



Glass barrier

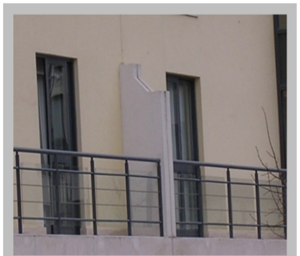


Glass barrier

Protected and unprotected

Incomplete protection

Glass barrier



Glass protection in a climbable barrier

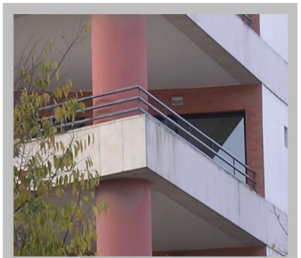
Passing-through toy

Passing-through toy

Vertical bars of reduced height

Footholds in vertical bars

Dangerous distance between bars



Easy to transpose barrier

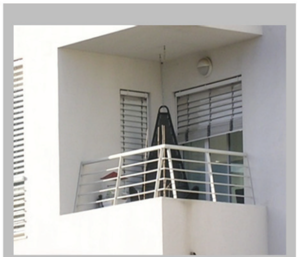
Plenty of footholds

A perfect climbing device

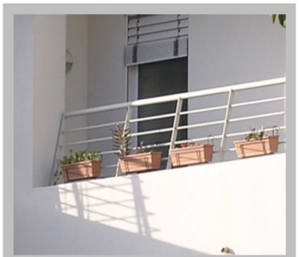
Open the window and climb

Additional height (first floor)

Footholds



Negative slope

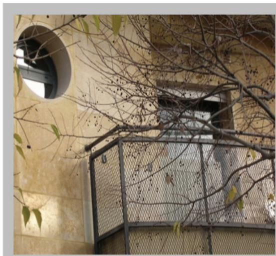


Negative slope

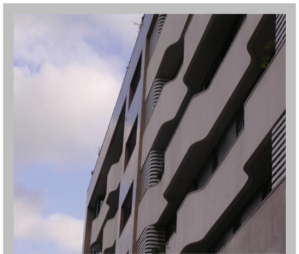
Traditional balconnies

Traditional designs with a negative sope

Traditional designs with a negative sope



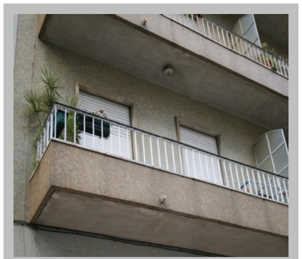
Grid-mesh pattern



Solid barrier

Solid barrier (around 1m)

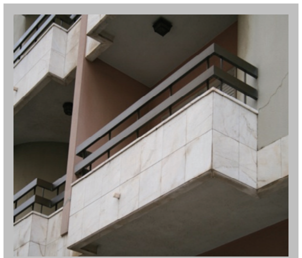
Grid-mesh pattern



Solid and vertical bars

Solid and vertical bars

Solid and vertical bars



Solid and horizontal bars

Solid and mixed bars

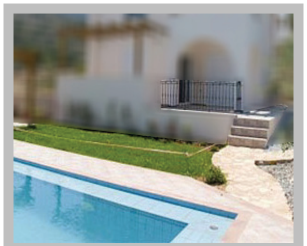
Natural footholds

Solid and fancy mixed bars

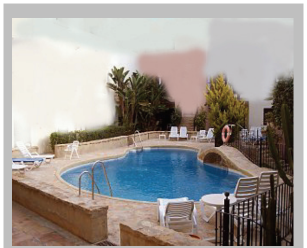
Solid and fancy mixed bars

Solid and bars

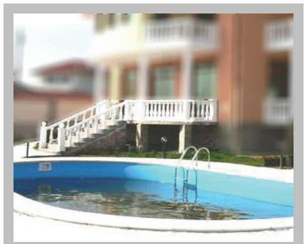
Easy access – no restrictions



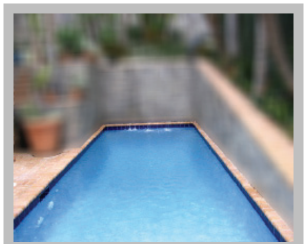
Easy access – no restrictions



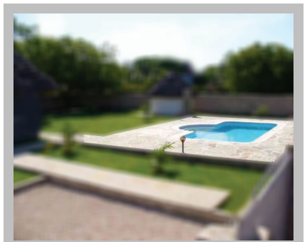
Soft restrictions



No restrictions



Jump into the water



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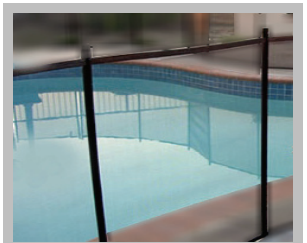
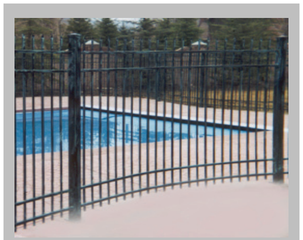


Glass panel barrier

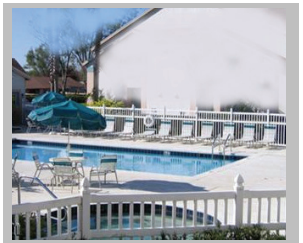
Glass panel barrier

Glass panel barrier

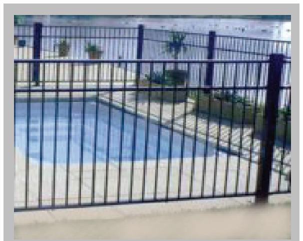
Footholds and stairs



Fence protection



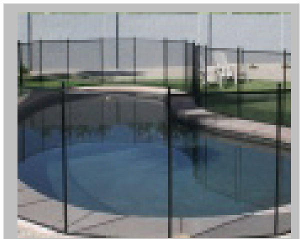
Decorative fence



Footholds ???

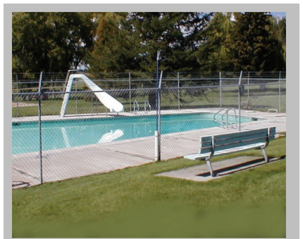
Fence protection

All-around fence



All-around glass panel

Height and fence protection



Mesh fence

APPENDIX 2

Press clips

Criança caiu de 3.º andar e morreu

ISALTINA PADRÃO
GONÇALO BORGES DIAS/ARQUIVO DN (imagem)

Um menino de três anos morreu ontem na sequência de uma queda de um terceiro andar, em Almeirim. "A criança ficou sozinha em casa enquanto os pais foram buscar o irmão, que é um ano mais velho, ao infantário", disse ao DN fonte da GNR de Almeirim que esteve no local.

Na Avenida D. João I, onde aconteceu a tragédia, instalou-se o pânico nas pessoas que assitiram à queda da criança da varanda da casa onde morava com os pais e o irmão. "No telefonema de alerta, feito pelas às 18.24, ainda se percebia, através da voz, o choque que se instalou nas pessoas que se aperceberam do ocorrido", contou ao DN fonte do Instituto Nacional de Emergência Médica (INEM), que enviou para o local uma viatura médica de emergência rápida (VMER) de Santarém.

De acordo com a mesma fonte, "a criança sofreu um traumatismo craniano grave e encontrava-se em paragem cardiorespiratória". No entanto, frisa, "ainda foram feitas manobras de reanimação mas sem qualquer sucesso, acabando por ser confirmado o óbito da criança no local".

Segundo o Centro Distrital de Operações de Socorro (CDOS) de Santarém, para o local da ocorrência foram mobilizadas duas viaturas dos Bombeiros Voluntários de Almeirim com quatro elementos, a GNR também de Almeirim e uma VMER de Santarém.

Outros casos

Em Setembro, uma menina de seis anos caiu de um primeiro andar, em Belas. Ficara em casa com mais duas irmãs (de quatro e dois anos) enquanto a mãe trabalhava - o que acontecia com frequência, segundo os relatos dos vizinhos. A menina ficou ferida, esteve internada, mas resistiu à queda. A Comissão de Protecção de Menores que levou mãe e filhas para um centro de acolhimento.

Há casos de autênticos "milagres". Como o de um bebé de 22 meses que sobreviveu, sem qualquer fractura, à queda do quarto andar do prédio n.º 125 da Rua Damião de Góis, em Braga, em 16 de Maio de 2006. Testemunhas do acidente comentaram então tratar-se de "um autêntico milagre".|

www.amigodopovo.com/not-div54.html

Queda aparatosa – Uma menina de quatro anos saiu praticamente ilesa de uma aparatosa queda da varanda de casa dos pais, situada no quarto andar de um bloco de apartamentos, em Spreintenbach, na Suíça. A criança desequilibrou-se e caiu sobre o relvado, depois de uma queda de 13 metros, enquanto observava as flores plantadas nos vasos do exterior da varanda. A menina foi transportada ao hospital de Zurique, onde efectuou vários exames médicos que não diagnosticaram nenhum ferimento grave.

Uma menina de quatro anos caiu ontem de manhã do quarto andar de um prédio em Massamá, concelho de Sintra, a uma altura de mais de 12 metros. A criança está internada em estado grave no Hospital de Santa Maria. Eram 10h00 quando o Instituto Nacional de Emergência Médica (INEM) foi alertado para a queda da menina. Na Praceta Manuel Faria, na zona da Cidade Desportiva de Massamá, poucos se aperceberam do desespero dos pais da pequena Cristiana. O casal habita no 4.º direito do lote 20 há pouco mais de sete anos. A menina terá trepado para a janela de onde se desequilibrou. Caiu no jardim localizado nas traseiras do edifício e, segundo fonte do INEM, sofreu um traumatismo craniano e outro no abdómen. A mesma fonte referiu que a menina perdeu muito sangue e foi levada para o Hospital de Santa Maria com acompanhamento médico. Ao início da noite o seu estado de saúde ainda não tinha sofrido alterações. Cristiana permanecia ontem à noite internada em estado grave. Os pais, desesperados, aguardavam melhores notícias dos médicos pediatras. Em Massamá, um vizinho que passeava o cão na rua e um outro morador do prédio viram a menina tombar, mas já nada puderam fazer para evitar a queda.

Barlavento a Sotavento

OLHÃO: criança de 16 meses sobrevive a queda de quinto andar

05-01-2007 16:27:00

Uma criança de 16 meses sobreviveu hoje a uma queda de um quinto andar de um prédio em Olhão, que terá sido amortecida por um carro.

Segundo declarações prestadas à agência LUSA por fonte do Hospital de Faro, a criança está internada nos Cuidados Intensivos de Pediatria, sofreu uma hemorragia cerebral, está estável e apresenta um prognóstico razoável.

O INEM tomou conta da ocorrência e deslocou para o local uma ambulância e uma viatura médica, onde a criança foi estabilizada, tendo sido depois encaminhada para o Hospital de Faro.

O acidente deu-se cerca das 10:00 e o facto de a criança ter caído em cima do automóvel pode ter amortecido o impacto da queda.

O Ribatejo – 18 de janeiro de 2008
Almeirim

Criança de três anos morre em queda do 3º andar

Um menino de três anos morreu na sequência de uma queda do 3º andar do prédio onde habitava, na Avenida D. João I, em Almeirim, no dia 21 de Dezembro. O pequeno Dylan Silva trepou o gradeamento da janela da sala e caiu desamparado no passeio, cerca das 18h30 da tarde. Um enfermeiro que passava no local e que estava fora de serviço prestou os primeiros socorros à criança, até à chegada dos bombeiros voluntários de Almeirim e da Viatura Médica de Emergência e Reanimação (VMER) do Hospital de Santarém. O óbito foi declarado às 18h55.

As circunstâncias que levaram ao acidente estão a ser investigadas pelo Ministério Público (MP) de Almeirim, que decidirá se vai deduzir acusação contra a mãe por alegada negligência. A criança estava sozinha em casa porque a mãe se ausentou por breves minutos para ir buscar o irmão mais velho, de quatro anos, ao jardim-de-infância, nas traseiras do prédio onde residem, a cerca de 300 metros. Apesar da consternação que o caso gerou na vizinhança, todos lhe tecem elogios e lamentam “a partida que o destino lhe pregou”. “Ela é uma mãe extremosa, sempre muito cuidadosa com os filhos”, garante Emília Carolino, proprietária de uma loja na esquina do prédio em frente. “Só posso dizer bem dela”, acrescenta um vizinho de um lote próximo, para quem “o acidente podia ter acontecido enquanto estava na cozinha ou foi à casa de banho”. Os vizinhos que falaram ao nosso jornal descrevem-na como uma pessoa “muito trabalhadora” e “simpática”, tal como o pai, que emigrou para a Bélgica à procura de emprego e não estava junto da família no dia do acidente. O funeral realizou-se apenas na véspera de Natal devido a um erro do na escala dos tribunais de turno; o processo da ocorrência foi enviado para o Tribunal de Santarém, quando devia ter sido remetido ao delegado do MP de serviço no Tribunal do Cartaxo. A autópsia foi realizada na segunda-feira e por “ter havido boa vontade para resolver o problema, tendo em conta que houve ponte da função pública”, adiantou ao nosso jornal uma fonte próxima do processo, reconhecendo que foi “uma situação confrangedora para a família”.

Four-story fall inspires push for 'Laela's Law'

Daily Record and the Kansas City Daily News-Press, Aug 7, 2006 by Bill Clements

Laela climbed into an open window from inside a fourth-floor apartment, leaned forward and tumbled 40 feet to the concrete below when a window screen broke. The little girl is recovering well, says her grandmother Janice Shaugobay, who describes Laela as a miracle. But not every infant or child who encounters a window screen in similar circumstances is as lucky. On April 20, in Southfield, Mich., 16-month-old Saviour Allah dropped 70 feet to his death after pushing through an open window's screen from inside his family's seventh-floor apartment. In this case, too, the infant climbed up to the window via furniture placed underneath an open window. Experts say parents should take steps to prevent such accidents by removing furniture or beds near windows. They also advise parents not to rely on screens built only to keep insects out by installing window guards or stops, which prevent windows from being raised more than 4 inches. Minnesota would become the first state to mandate the use of stronger, security-type window screens for some new developments under a bill that is expected to be introduced next year. State Sen. Linda Berglin is writing legislation that would require sturdier screens for windows in new multiunit residential buildings of more than two stories. We're also looking into the possibility of requiring these screens for all rehabbed and retrofitted multiunit buildings, Berglin says. She'd like to push the bill through the Legislature in 2007, although she expects to encounter industry opposition in the beginning. Critics claim that screens are built only to keep bugs out, and building stronger ones will sharply increase the cost of manufacturing screens. Conventional screens cost about $10, and security screens cost $60 to $100. Berglin says the stronger screens are cheaper in the long run. Most multiunit buildings encounter quite a lot of expense in replacing existing screens, she says. So because these security screens are so sturdy and durable, they won't have to be replaced and will save money long term. Berglin says that is the message she plans to convey to builders and landlords.

BBC News July, 31 2007

Head guilty over boy's fatal fall

A headmaster has been found guilty of breaching health and safety laws after the death of a three-year-old pupil.

Kian Williams died in August, 2004, a month after jumping off steps at Hillgrove, a private school in Bangor, Gwynedd, while pretending to be Batman.

James Porter, 66, was convicted by an 11-to-one majority after a seven-day trial at Mold Crown Court.

The judge, who will fine the head later, said unsupervised access exposed Kian and other children to risk.

Kindergarten pupil Kian, from Bethesda, had been carrying a Spiderman toy when he jumped from the fourth step from the bottom of the flight.

He landed face forwards, causing head injuries which led to a coma and pneumonia, and died in hospital a month later.

The court was told the pneumonia that Kian had developed had been a strain of MRSA resistant to antibiotics, and there could be "no doubt" the infection had caused Kian's death.

The jury was told there had been only one teacher on duty supervising 59 pupils when the incident happened during the morning break.

The teacher had positioned herself so she could supervise both upper and lower playgrounds.

"Schools and nurseries should be safe environments where parents feel totally safe leaving their children "

Jacqueline Williams, mother

Last Updated: Tuesday, July 17, 2007 | 7:12 PM ET

Toronto child dies in fall from highrise

CBC News

A two-year-old boy has died after falling 11 storeys from a Toronto highrise balcony Tuesday morning.

Police said the child fell from a building on Shuter Street in the Regent Park area just after 8 a.m. ET. He suffered head injuries and was declared dead after being taken to hospital.

The boy’s mother and two other children were home when the boy fell, police said.

Workers with Toronto emergency services told CBC News that they have responded to 10 calls of falling children since May.

They urged parents to be vigilant in supervising near windows, balconies and decks. Windows should be fitted with locks to prevent them from opening more than 10 centimetres.

At a news conference Tuesday, Toronto police also urged parents to explain the dangers of falls from windows or balconies to their children.

The Chronicle of Higher Education

A CASE TO CONSIDER

Are Your Old Buildings Dangerous?

By WILLIAM P. HOYE
Henricksen v. State (2004)

In November 1995 a 3-year-old child named Hunter slipped between the stairway balusters of a second-story open stairwell at the Montana State University at Bozeman library. He fell about 20 feet, landing on the left side of his head on the concrete floor below.

NRMA CareFlight

Toddler drowns in backyard pool (Kenthurst)

Ian Badham
26th December 2007, 12:30pm

Desperate efforts by his parents and medics were unable to revive a year-old boy who drowned in his family's backyard pool at Kenthurst, in Sydney's north-west, today.

Ambulance officers alerted NRMA CareFlight to the incident following a "000" phone call at 10.20 am.

The toddler's mother and father were carrying out CPR when the NRMA CareFlight doctor landed at the house, with ambulance paramedics joining the resuscitation effort.

This is the third drowning of a child in a backyard pool which NRMA CareFlight trauma teams have attended this summer.

NRMA CareFlight

Young children survive balcony fall (Greenacre)

Ian Badham
23rd December 2007, 5:00pm

Two young children were taken to hospital suffering head injuries after they fell from the balcony of a unit a Greenacre, in Sydney's south west, today.

Ambulance officers and an NRMA CareFlight trauma team rushed to the children at Waterloo Street after being alerted to their plight with a "000" call at 3.45 pm today.

The NRMA CareFlight doctor said the four-year-old girl and three-year-old boy fell three metres form the balcony.

Initially reported as unconscious the girl was semi-conscious when the trauma doctor landed in an adjacent block of land minutes after the alert, while the boy escaped with minor injuries.

Both were taken to the Westmead Children's Hospital for observation, in a stable condition.

San Francisco Chronicle

2 children drown in their backyard swimming pool

Saturday, October 27, 2007

An Antioch woman who left her two young children playing alone in the backyard Friday returned after a few minutes to find the siblings had gotten past a security fence and drowned in the family's swimming pool, authorities said. Three-year-old Victor Cano and his 22-month-old sister, Adamari Cano, were pulled from the pool on the 1100 block of East 13th Street about 12:35 p.m., authorities said. They were taken to Sutter Delta Medical Center in Antioch, where they were pronounced dead.

Authorities said the children had been playing in the backyard when their mother, 21-year-old Daniela Espinosa, went inside to use the restroom. When she came out several minutes later, she could not see the children, then realized they were in the pool, authorities said.

She told police that the children had not been playing near the pool when she went inside the house. The security fence sets off the pool from the rest of the yard, but Victor and Adamari, who would have turned 2 in December, somehow managed to get past it.

Espinosa screamed and jumped in the water, and neighbors ran to help and called 911. The water was murky and green, however, and authorities said the mother initially had difficulty finding her children.

She had pulled them out of the water, unconscious and not breathing, by the time rescue workers arrived. It's unclear how long the children were in the pool.

Associated Press - January 10, 2008 1:35 PM ET

Toddler drowns in backyard swimming pool

COLLEYVILLE, Texas (AP) - A suburban Fort Worth toddler has apparently drowned after falling into a backyard swimming pool.

The Tarrant County Medical Examiner's Office identified the dead girl as Dylan Barnard of Colleyville, who would have turned age two tomorrow. She was pronounced dead last night at Cook Children's Medical Center in Fort Worth.

Colleyville officials say Dylan and an older sibling had been playing near the front of their home when the older child went inside. Dylan didn't follow. Within seconds, Dylan's mother found her unconscious in the family's backyard swimming pool and pulled her out.

Another child dies in a family swimming pool

Alex Tibbitts
December 14, 2007

A THREE-YEAR-OLD girl has drowned in the Southern Highlands, taking the number of child drownings in Australia to 11 in the past fortnight.

Last week a two-year-old girl drowned in an inflatable pool in Curl Curl.

The Royal Life Saving Society last month released its 2007 National Drowning Report, which revealed that 35 infants and toddlers had drowned in 2006-07

The latest victim was discovered in the family's fenced pool in Hawthorn Road, Bargo, by her elder brother last night, a neighbour said. He had alerted his mother, the neighbour said.

Nearby residents including a nurse performed resuscitation for 10 minutes until police arrived, followed by ambulance officers about 15 minutes later.

"Police officers attempted CPR on the child until she was taken by ambulance to Campbelltown Hospital, but she died en route," a police spokeswoman said.

Police remained at the house to continue their inquiries for the coroner's report, but said there were no suspicious circumstances. The girl's father, a truck driver, was away when the accident occurred.

The Royal Life Saving Society has called child drownings a national tragedy and has urged parents to redouble their water safety efforts. Of the 11 children who have drowned in the past fortnight, three were toddlers.

Last week Maia Comas was found floating face down in 15 centimetres of water in the front yard of her Curl Curl home.

A neighbour tried to resuscitate her before paramedics arrived. She was taken to Mona Vale Hospi-tal unconscious but could not be revived.

The society is trying to highlight the issue through its Keep Watch program. “The Keep Watch campaign reminds backyard pool owners of the importance of restricting a child’s access … and constantly supervising children when they are in, on or around the pool,” said the society’s chief executive, Rob Bradley.

“Parents mistakenly believe they can listen out and will hear their child drowning. Drowning is swift and silent; it is not generally accompanied by children crying out or splashing.”

Of the 35 children under five who drowned in 2006-07, 16 drowned in swimming pools, of which 15 were home pools; six drowned in bathtubs; and 23 fell or wandered into water.

Yesterday a toddler who wandered off was saved by his family’s dogs near Mackay in Queensland. Police said an Andergrove woman had found the two-year-old and the dogs, a Rottweiler-cross and a Staffordshire terrier, on the embankment of her dam about 11am.

The boy was covered in mud, had marks on his upper arms, and there were drag marks in the mud, consistent with the dogs having pulled him out of the water.

Toddler Dies After Five-Story Balcony Fall

POSTED: 7:35 am EST December 7, 2004
UPDATED: 12:44 pm EST December 7, 2004

MIAMI — Investigators are trying to find out how a 16-month-old boy was able to get out of a Miami apartment and scale a fifth-floor balcony railing before falling to his death when his aunt and grandmother were supposed to be watching him.

Javan Trujillo landed on asphalt below the apartment along Northwest 2nd Street and 12th Avenue. He died at Jackson Memorial Hospital.

Police said the child's grandmother, Marta Serrano, 37, and his aunt, Jeannie Paz, 18, were babysitting when the accident happened. Apparently, they didn't realize where the child was.

"There was a chair on the balcony, in fact two chairs. So, you could speculate that the child got up on the chair and was able to get over the railing," said Miami Police Lt. Bill Schwartz.

Police said Serrano and Paz will not be charged.

Friends and family have left flowers, candles and Teddy bears outside the apartment. The child lived there with his grandmother, aunt, mother and great-grandfather.

Local News

Posted on: Thursday, January 12, 2006

Child may have climbed railing

By Mike Gordon
Advertiser Staff Writer

A toddler who fell to his death from a hotel balcony may have climbed over the safety railing instead of squeezing through its vertical protective slats, as was previously thought, the city medical examiner's office said yesterday.

But the boy's father, David Shpigler, stood by the family's account that 3-year-old Samuel Shpigler somehow got through a 5-inch-wide gap between the balcony railing slats before falling eight stories to the ground New Year's Day.

"That's not what happened," David Shpigler said by telephone from his office in Nyack, N.Y. "He went through the slats. The fact that they are not able to rule it out does not change what happened."

The city's Department of the Medical Examiner last week concluded that the boy's cause of death was "multiple internal injuries due to a fall from a height" and was ruled an accident.

But Dr. William Goodhue, the city's first deputy medical examiner, wanted to revisit the balcony of the Ali'i Tower of the Hilton Hawaiian Village. On Jan. 3, he and an investigator measured the slat widths and railing height and his investigator interviewed the Shpiglers and their children.

"We took appropriate measurements at the scene," Goodhue said yesterday. "This information and my autopsy findings lead me to say that I cannot exclude that Samuel Shpigler may have climbed over the railing of their hotel room balcony and fallen to his death."

LANAI SAFETY

Tips for parents of small children who live in high-rises:

Make sure there is no furniture on the lanai that a child could climb.

If the balcony railing has vertical slats, make sure the space between the slats is no more than 4 inches wide.

Cover and lock windows within a toddler's reach with grilles or child-proof screens.

Always supervise children when they are on the lanai.

The best way to make sure nothing happens is to lock the balcony door.

Source: State Department of Health

Goodhue would not elaborate further, stating that his conclusions will be part of the written autopsy report when it is released in about four weeks.

Samuel Shpigler had gotten out on the balcony with two young siblings without the rest of the family knowing. Honolulu police have said that the only witness was the oldest of those siblings — a 6-year-old boy.

”We have spoken to them many times,” said David Shpigler, who buried his youngest son Monday. “They have been very consistent in what they told us.”

Shpigler said the children were not allowed on the hotel room’s balcony without adult supervision.

”They were out there when we were not aware they were out there,” he said. “They were able to open the door and get out there. When you check into a hotel room they give you a key to the minibar, but they don’t give you a key to the balcony. Children are safe from getting to alcohol but not from getting on the balcony.”

Cynthia Rankin, a spokeswoman for the Hilton, yesterday said the hotel rooms do not come with keys to the sliding glass door on the balcony. However, they do have a double latching system to secure the door.

”There are building codes that require what is necessary for locks on doors and what is needed for railings,” Rankin said. “Hilton Hawaiian Village is complying with building codes. A physical key that you can put in your pocket is not a building code requirement. It isn’t in any hotel in Hawai’i.”

At 5 inches wide, the gap between the vertical slats on the balcony meets city building codes, but based on an outdated standard not used since 1997.

The 5-inch gap would not be allowed under new construction. It’s legal, though, because the hotel followed city building codes in effect when the railings were first installed.

City building codes now state the gap between vertical slats installed in new buildings, or as part of a remodeling job, cannot be wider than 4 inches.

The handrail also has a minimum height mandated by city building codes: 42 inches. Henry Eng, director of the city's Department of Planning and Permitting, said yesterday that the Ali'i Tower meets that standard. The hotel confirmed that.

Shpigler described his son as "average-sized." He did not think that a 5-inch-wide gap was narrow enough to hold back his son.

After the accident, Shpigler measured the head of another child who was on the balcony that day — his daughter, who is nearly 5 years old. Her head is exactly 5 inches wide, Shpigler said. That helped convince him that his younger son could fit between the slats.

Eric Tash, manager of the state Department of Health's Injury Prevention Program, said parents need to be more aware of the dangers of balconies.

The most important thing is to make sure they are never alone on the balcony, Tash said. Parents also should remove furniture that would allow a child to climb over a railing, he said.

And Tash said to lock the door if possible.

"Kids are very inquisitive and they move quickly," Tash said. "We recommend that they be supervised. But sometimes it is not always possible to do that so you want to make the area as child-safe as possible."

Child survives 3-storey fall

Max Harrold, The Gazette

Published: Thursday, July 26 2007

After treating the fourth child to arrive at Ste. Justine Hospital this month after plunging from an apartment window, trauma specialist Dickens St. Vil said Thursday that parents need to get the message:

“Keep young children away from windows.

“Don’t let the windows open more than a foot.”

The simple, blunt warning came after Sam-Jeffrey St. Pierre, 4, was rushed to Ste. Justine on Wednesday night after falling out of his bedroom window in Montreal North and hitting the pavement about seven metres below. He was playing with his 6-year-old brother on their bunk bed next to the window when the screen gave way.

Sam-Jeffrey survived only through some “aggressive resuscitation” involving intubation because he could not breathe, St. Vil said.

The boy remained in intensive care yesterday with severe head injuries and a broken left leg.

St. Vil said the three other children - two boys and a girl - whom Ste. Justine has treated after falls from windows this month had severe head trauma and all might have long-term damage that will require therapy for months, if not years.

Normally, the hospital treats about 10 of these cases per year.

“Window screens do not prevent falls,” said St. Vil, 47. “Window bars and barriers do.”

Besides Sam-Jeffrey, St. Vil treated a 5-year-old boy who fell from a second-floor balcony on Tuesday and a 2-year-old girl who fell from a third-floor window on July 12.

The doctor also treated a 2-year-old boy who fell from a fourth-floor window in St. Laurent on July 5. That boy was released Thursday but will require follow-up treatment for broken facial bones and broken teeth, St. Vil said.

Montreal Children's Hospital officials could not be reached Thursday to provide an update on such cases it has treated this summer. But this month, the hospital said it has treated about 50 children in the past decade who had fallen from windows.

Children who fall from heights tend to be boys and many are from poorer neighbourhoods, St. Vil said.

"It's not because I want to judge them, but parents from these areas tend to be busier and don't always have the means" to take precautions, he said.

Alaine Francois, Sam-Jeffrey's mother, was tired and had tears welling in her eyes Thursday as she described her son's fall.

"I love him so much." She realized the bed's placement next to the window was a mistake, she said, but was too focused on her son's condition Thursday to dwell on what caused the accident.

As he fell, the boy hit some electric cables that are strung tightly across the alley behind the apartment building. That probably reduced the impact of his fall, said the building's owner, Carl Dubuche, 42.

"The lights blinked in the building," Dubuche said. "It's a miracle he's still alive."

Following this latest incident, Montreal police Constable Laurent Gingras underscored how important it is for parents to supervise their children, keep furniture away from windows and take precautions - like installing window guards, which are sold in hardware stores.

"This is common sense," Gingras said. "These accidents are preventable."

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APPENDIX 3

Reference standards of the Euro-Growth Study, WHO, NHANES and RAPIL

Table 1 - Reference standards of the Euro-Growth Study, WHO and NHANES for 12 MONTHS children and mean values, standard deviation, maximum and minimum of the children of our study.

12 months			Euro-Growth					WHO					NHANES*					RAPIL					This Study ♂=9; ♀=2			
			P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	Mean	SD	Max	Min
Reaching	M. V. R.	♂																					**91.1**	3.6	95.5	85.0
		♀																					**95.0**	0.0	95.0	895.0
	A. D. L.	♂																					**33.0**	0.9	34.1	31.9
		♀																					**32.3**	3.0	34.4	30.1
	T. H.	♂																					**36.2**	1.7	39.6	33.8
		♀																					**33.5**	3.0	35.6	31.3
	Stature	♂	72.0	72.9	**76.0**	79.2	80.0	71.8		**75.7**		79.7	73.9	74.8	**80.9**	86.7	88.9						**80.0**	2.9	83.7	75.6
		♀	70.7	71.7	**74.7**	78.0	78.9	69.8		**74.0**		78.3	_	74.2	**80.2**	_	_						**79.1**	0.6	79.5	78.7
Passing Through	H. C.	♂	44.9	45.4	**47.0**	49.0	49.3	44.0		**46.1**		48.2											**47.9**	1.0	49.6	46.2
		♀	43.9	44.3	**46.0**	47.5	48.0	42.7		**44.9**		47.1											**46.8**	0.5	47.1	46.4
	B. B.	♂																					**13.0**	0.5	14.0	12.2
		♀																					**12.6**	0.2	12.7	12.4
	A.P.C.B.	♂																					**11.6**	0.7	12.9	10.6
		♀																					**10.4**	0.3	10.6	10.2
Grasping, Strength and Body mass	H. L.	♂																					**9.6**	0.4	10	9.1
		♀																					**8.8**	0.0	8.8	8.8
	Weight	♂	8.6	9.0	**10.2**	11.7	12.2	8.1		**9.6**		11.5	8.9	9.5	**11.1**	13.1	13.4						**11.4**	1.1	13.2	9.7
		♀	8.0	8.3	**9.5**	11.1	11.6	7.3		**8.9**		11.0	_	9.1	**10.6**	12.9	_						**10.9**	0.5	11.2	10.5

*(12-23 months), Maximum Vertical Reaching (MVR), Acromiale-Dactylion Lenght (ADL), Trochanterion Height (TH), Stature, Head Circumference (HC), Biparietal Breadth (BB), A-P Chest Breadth (APCB), Midstylion-Dactylion Lenght(HL), Weight.

Table 2 - Reference standards of the Euro-Growth Study, WHO and NHANES for 24 MONTHS children and mean values, standard deviation, maximum and minimum of the children of our study.

24 months			Euro-Growth					WHO					NHANES					RAPIL					This Study ♂=12; ♀=8			
			P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	Mean	SD	Max	Min
Reaching	M. V. R.	♂																					**105.1**	7.8	120.1	94.5
		♀																					**103.0**	5.5	115.0	96.3
	A. D. L.	♂																					**37.2**	2.3	40.5	33.2
		♀																					**36.5**	1.9	40.5	33.9
	T. H.	♂																					**41.4**	2.6	44.6	37.4
		♀																					**40.0**	3.1	46.1	36.1
	Stature	♂	83.0	84.2	**88.0**	91.9	93.0	82.1		**87.1**		92.1		84.7	**91.0**	97.6							**89.4**	4.3	95.6	81.7
		♀	82.0	83.5	**87.1**	91.0	92.6	80.4		**85.7**		91.0		84.9	**89.7**	95.3							**88.3**	4.4	97.8	85.2
Passing Through	H. C.	♂	47.0	47.5	**49.5**	51.2	51.8	46.0		**48.3**		50.0											**48.5**	2.8	50.1	39.9
		♀	46.0	46.7	**48.4**	50.0	50.0	44.9		**47.2**		49.5											**48.9**	1.0	50.4	47.6
	B. B.	♂																					**13.0**	0.5	13.8	12.3
		♀																					**12.6**	0.4	13.2	11.9
	A.P.C.B.	♂																					**12.0**	0.5	13.1	11.3
		♀																					**11.1**	0.5	11.9	10.4
Grasping, Strength and Body mass	H. L.	♂																					**10.4**	0.6	11.0	9.2
		♀																					**10.1**	0.6	10.9	9.2
	Weight	♂	10.7	11.2	**12.8**	14.6	15.3	10.1		**12.2**		14.7	11.1	11.5	**13.7**	15.9	16.8						**14.3**	1.3	16.3	12.5
		♀	10.2	10.7	**12.3**	14.4	15.0	9.4		**11.5**		14.2	_	11.1	**12.9**	15.6	_						**13.3**	2.2	18.0	10.9

Maximum Vertical Reaching (MVR), Acromiale-Dactylion Lenght (ADL), Trochanterion Height (TH), Stature, Head Circumference (HC), Biparietal Breadth (BB), A-P Chest Breadth (APCB), Midstylion-Dactylion Lenght(HL), Weight.

Table 3 - Reference standards of the Euro-Growth Study, WHO and NHANES for 3 YEARS children and mean values, standard deviation, maximum and minimum of the children of our study.

3 Years			Euro-Growth					WHO					NHANES					RAPIL					This Study ♂=3; ♀=8			
			P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	Mean	SD	Max	Min
Reaching	M. V. R.	♂																					**116.7**	1.5	118.0	115.0
		♀																					**126.7**	6.5	137.7	117.8
	A. D. L.	♂																					**40.8**	1.1	42.0	39.8
		♀																					**43.2**	2.2	46.3	39.8
	T. H.	♂																					**46.7**	0.6	47.3	46.1
		♀																					**49.5**	3.1	54.7	45.7
	Stature	♂	91.4	92.5	**97.0**	101.5	102.9	90.0		**96.1**		102.2		92.5	**98.8**	103.9							**95.2**	1.6	96.4	93.4
		♀	90.1	91.6	**96.0**	101.3	102.5	88.8		**95.1**		101.3		92.6	**98.1**	102.2							**102.5**	4.4	109.7	96.4
Passing Through	H. C.	♂	48.0	48.6	**50.6**	52.5	53.0	47.1		**49.5**		51.8											**50.1**	0.1	50.2	50.0
		♀	47.2	47.8	**49.5**	51.1	51.9	46.2		**48.5**		50.8											**49.7**	1.4	51.8	48.1
	B. B.	♂																					**13.2**	0.2	13.4	13.0
		♀																					**13.4**	0.5	13.9	12.7
	A.P.C.B.	♂																					**12.4**	0.3	12.7	12.1
		♀																					**12.3**	0.5	13.0	11.5
Grasping, Strength and Body mass	H. L.	♂																					**10.8**	1.0	11.7	9.8
		♀																					**11.6**	0.4	12.2	11.0
	Weight	♂	12.7	13.2	**15.0**	17.5	18.1	11.8		**14.3**		17.5		12.9	**16.0**	18.8							**15.0**	1.8	16.6	13.1
		♀	12.4	12.8	**14.7**	17.2	18.1	11.3		**13.9**		17.3		12.9	**15.0**	17.5							**15.9**	2.0	18.7	13.4
	Strength (♂=1; ♀=8)	♂																					**3**	0	3	3
		♀																					**5.1**	2.0	8.5	2.3

Maximum Vertical Reaching (MVR), Acromiale-Dactylion Lenght (ADL), Trochanterion Height (TH), Stature, Head Circumference (HC), Biparietal Breadth (BB), A-P Chest Breadth (APCB), Midstylion-Dactylion Lenght(HL), Weight, Strength.

Table 4 - Reference standards of the WHO, NHANES and RAPIL for 4 YEARS children and mean values, standard deviation, maximum and minimum of the children of our study.

4 Years			Euro-Growth					WHO					NHANES					RAPIL ♂=65; ♀=71					This Study ♂=6; ♀=8			
			P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	Mean	SD	Max	Min
Reaching	M. V. R.	♂																					**133.7**	8.2	144.3	121.5
		♀																					**131.7**	5.9	140.6	123.7
	A. D. L.	♂																41.5	42.1	**44.4**	47.6	48.7	**46.5**	3.1	50.1	42.1
		♀																40.1	40.7	**43.4**	46.7	47.7	**44.4**	2.0	47.5	41.0
	T. H.*	♂																45.2	45.3	**46.5**	49.2	50.3	**53.2**	3.2	59.0	50.2
		♀																43.1	43.9	**46.4**	48.3	48.7	**52.0**	2.3	56.4	48.5
	Stature	♂						96.4		**103.3**		110.2		100.7	**106.5**	112.1		99.9	101.2	**106.3**	112.	114.4	**107.6**	5.6	116.5	100.0
		♀						95.6		**102.7**		109.8		100.3	**105.8**	111.7		96.6	98.5	**104.9**	110.7	112.3	**105.8**	3.6	112.1	101.6
Passing Through	H. C.	♂						47.8		**50.2**		52.6											**51.2**	0.9	52.7	50.2
		♀						47.0		**49.3**		51.7											**50.8**	1.1	52.0	49.2
	B. B.	♂																					**14.2**	0.5	14.7	13.4
		♀																					**13.5**	0.6	14.2	12.6
	A.P.C.B.	♂																10.8	11.3	**12.4**	14.3	15.2	**12.8**	0.5	13.6	12.3
		♀																10.5	10.8	**12.0**	13.2	13.6	**12.4**	0.7	13.5	11.5
Grasping, Strength and Body mass	H. L.	♂																					**12.0**	0.7	12.5	10.6
		♀																					**11.9**	0.7	12.9	10.8
	Weight	♂						13.3		**16.3**		20.2		15.4	**18.2**	21.4		13.3	14.0	**17.1**	21.8	23.5	**18.6**	1.8	20.2	16.0
		♀						12.9		**16.1**		20.4		14.7	**17.2**	20.8		13.4	14.0	**16.5**	19.8	21.0	**17.4**	2.3	21.3	14.0
	Strength (♂=6; ♀=7)	♂																					**8.3**	3.4	12.5	4.0
		♀																					**6.9**	2.3	8.5	2.3

Maximum Vertical Reaching (MVR), Acromiale-Dactylion Lenght (ADL), Trochanterion Height (TH), Stature, Head Circumference (HC), Biparietal Breadth (BB), A-P Chest Breadth (APCB), Midstylion-Dactylion Lenght(HL), Weight, Strength.

* T.H. RAPIL corresponds to the difference between stature and sitting height and T.H. in our study it corresponds to trochanterion height.

Table 5 - Reference standards of the WHO, NHANES and RAPIL for 5 YEARS children and mean values, standard deviation, maximum and minimum of the children of our study.

5 Years			Euro-Growth					WHO					NHANES					RAPIL ♂=89; ♀=68					This Study ♂=16; ♀=13			
			P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	Mean	SD	Max	Min
Reaching	M. V. R.	♂																					**142.3**	8.9	161.8	125.0
		♀																					**138.3**	6.3	145.0	126.0
	A. D. L.	♂																44.0	44.8	**47.9**	51.4	52.5	**49.1**	3.1	55.9	43.1
		♀																43.1	43.9	**46.8**	50.5	51.7	**47.0**	2.4	50.3	42.7
	T. H.*	♂																47.7	48.2	**50.6**	53.8	54.8	**56.2**	4.3	65.0	48.4
		♀																47.6	48.2	**50.5**	53.4	54.3	**55.1**	2.8	58.9	50.1
	Stature	♂						102.3		**110.0**		117.6		105.8	**114.2**	119.1		103.5	105.6	**112.5**	118.6	120.3	**115.6**	10.5	144.1	100.4
		♀						101.6		**109.4**		117.2		106.5	**111.9**	119.5		102.5	104.2	**110.8**	117.9	119.9	**111.6**	4.3	116.4	103.4
Passing Through	H. C.	♂						48.3		**50.7**		53.2											**52.1**	1.0	54.0	50.2
		♀						47.6		**49.9**		52.3											**50.7**	1.5	52.6	49.0
	B. B.	♂																					**14.1**	0.6	15.3	13.1
		♀																					**13.6**	0.6	14.3	12.5
	A.P.C.B.	♂																11.4	11.6	**12.9**	14.6	15.6	**13.0**	0.6	13.8	12.0
		♀																10.3	11.1	**12.6**	13.9	14.9	**12.6**	0.8	14.2	11.4
Grasping, Strength and Body mass	H. L.	♂																					**12.6**	0.8	14.4	11.0
		♀																					**12.4**	0.8	13.6	11.2
	Weight	♂						14.7		**18.3**		23.0		17.0	**20.7**	26.0		15.2	16.1	**20.0**	26.2	28.7	**20.6**	3.5	30.8	15.0
		♀						14.4		**18.2**		23.5		16.6	**19.2**	26.9		14.6	15.4	**18.9**	24.4	26.7	**19.8**	3.1	23.2	13.7
	Strength	♂																					**9.7**	3.4	19.3	5.5
		♀																					**8.5**	2.3	12.5	5.5

Maximum Vertical Reaching (MVR), Acromiale-Dactylion Lenght (ADL), Trochanterion Height (TH), Stature, Head Circumference (HC), Biparietal Breadth (BB), A-P Chest Breadth (APCB), Midstylion-Dactylion Lenght(HL), Weight, Strength.
* T.H. RAPIL corresponds to the difference between stature and sitting height and T.H. in our study it corresponds to trochanterion height.

Table 6 - Reference standards of the NHANES and RAPIL for 6 YEARS children and mean values, standard deviation, maximum and minimum of the children of our study.

6 Years			Euro-Growth					WHO					NHANES					RAPIL ♂=207; ♀=223					This Study ♂=4; ♀=2			
			P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	P5	P10	P50	P90	P95	Mean	SD	Max	Min
Reaching	M. V. R.	♂																					**151.3**	6.1	158.3	145.3
		♀																					**150.2**	3.3	152.5	147.8
	A. D. L.	♂																46.3	47.3	**50.9**	54.7	55.7	**51.6**	2.7	53.9	48.6
		♀																45.7	46.6	**49.9**	53.8	55.0	**50.6**	1.1	51.4	49.8
	T. H.*	♂																50.4	51.2	**54.4**	57.8	58.8	**61.1**	2.1	63.0	58.8
		♀																51.3	51.9	**54.3**	57.8	59.0	**60.8**	1.6	61.9	59.7
	Stature	♂												111.6	**119.3**	125.9		109.7	111.7	**118.5**	124.9	126.6	**120.8**	3.1	123.7	117.8
		♀												110.2	**117.2**	124.0		108.5	110.4	**117.1**	123.9	125.9	**119.6**	3.1	121.8	117.4
Passing Through	H. C.	♂																					**51.3**	0.7	52.3	50.7
		♀																					**51.1**	0.4	51.3	50.8
	B. B.	♂																					**13.9**	0.5	14.4	13.2
		♀																					**13.5**	0.3	13.7	13.3
	A.P.C.B.	♂																11.8	12.2	**13.2**	15.0	15.8	**13.2**	0.7	13.7	12.1
		♀																11.6	11.8	**13.3**	15.2	16.1	**12.6**	0.7	13.1	12.1
Grasping, Strength and Body mass	H. L.	♂																					**13.2**	0.9	14.3	12.1
		♀																					**13.4**	0.1	13.4	13.3
	Weight	♂												18.2	**22.7**	29.0		17.1	18.0	**22.7**	30.5	33.8	**24.0**	4.4	30.4	21.0
		♀												17.9	**21.5**	27.7		16.3	17.3	**21.8**	29.4	32.6	**22.6**	2.1	24.0	21.1
	Strength	♂																					**10.6**	1.7	12.8	8.8
	(♂=4; ♀=1)	♀																					**7.5**	0	7.5	7.5

Maximum Vertical Reaching (MVR), Acromiale-Dactylion Lenght (ADL), Trochanterion Height (TH), Stature, Head Circumference (HC), Biparietal Breadth (BB), A-P Chest Breadth (APCB), Midstylion-Dactylion Lenght(HL), Weight, Strength.
* T.H. RAPIL corresponds to the difference between stature and sitting height and T.H. in our study it corresponds to trochanterion height.

APPENDIX 4

Success and failure in crossing different barriers

Success and failure in crossing different barriers

	Frequency (no help)	Valid Percent (no help)	Frequency (with boxes)	Valid Percent (with boxes)
Barrier A-1 – Failure	10	100	10	100
Barrier A-1 – Success	0	0	0	0
Barrier B-1 – Failure	8	80	8	80
Barrier B-1 – Success	2	20	2	20
Barrier C-1 – Failure	10	100	10	100
Barrier C-1 – Success	0	0	0	0
Barrier D-2 – Failure	9	30	8	26,7
Barrier D-2 – Success	21	70	22	73,3
Barrier E-2 – Failure	23	76,7	20	66,7
Barrier E-2 – Success	7	23,3	10	33,3
Barrier F-2 – Failure	27	90	27	90
Barrier F-2 – Success	3	10	3	10
Barrier G-3 – Failure	7	16,3	7	16,3
Barrier G-3 – Success	36	83,7	36	83,7
Barrier H-3 – Failure	16	36,4	15	34,1
Barrier H-3 – Success	28	63,6	29	65,9
Barrier I-3 – Failure	25	56,8	17	38,6
Barrier I-3 – Success	19	43,2	27	61,4
Barrier J-3 – Failure	28	65,1	27	62,8
Barrier J-3 – Success	15	34,9	16	37,2
Barrier K-3 – Failure	2	4,7	2	4,7
Barrier K-3 – Success	41	95,3	41	95,3
Barrier L-3 – Failure	10	26,3	10	26,3
Barrier L-3 – Success	28	73,7	28	73,7
Barrier M-3 – Failure	29	55,8	23	44,2
Barrier M-3 – Success	23	44,2	29	55,8
Barrier N-3 – Failure	27	52,9	22	43,1
Barrier N-3 – Success	24	47,1	29	56,9