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.

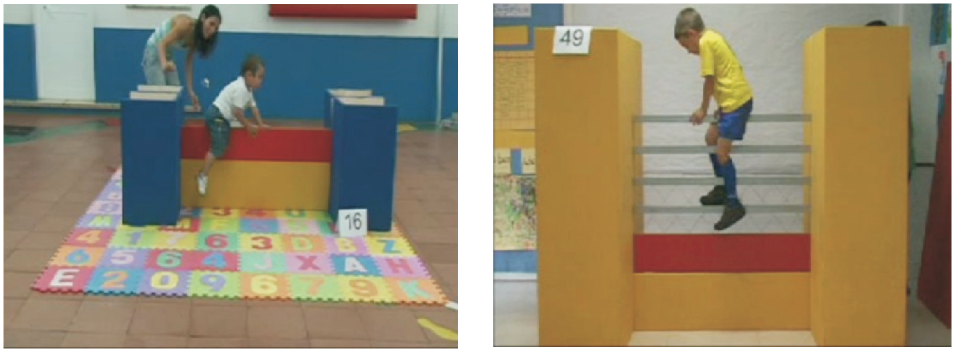


Figure 3 - Action mode 1 (HOW – Head over waist).

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.

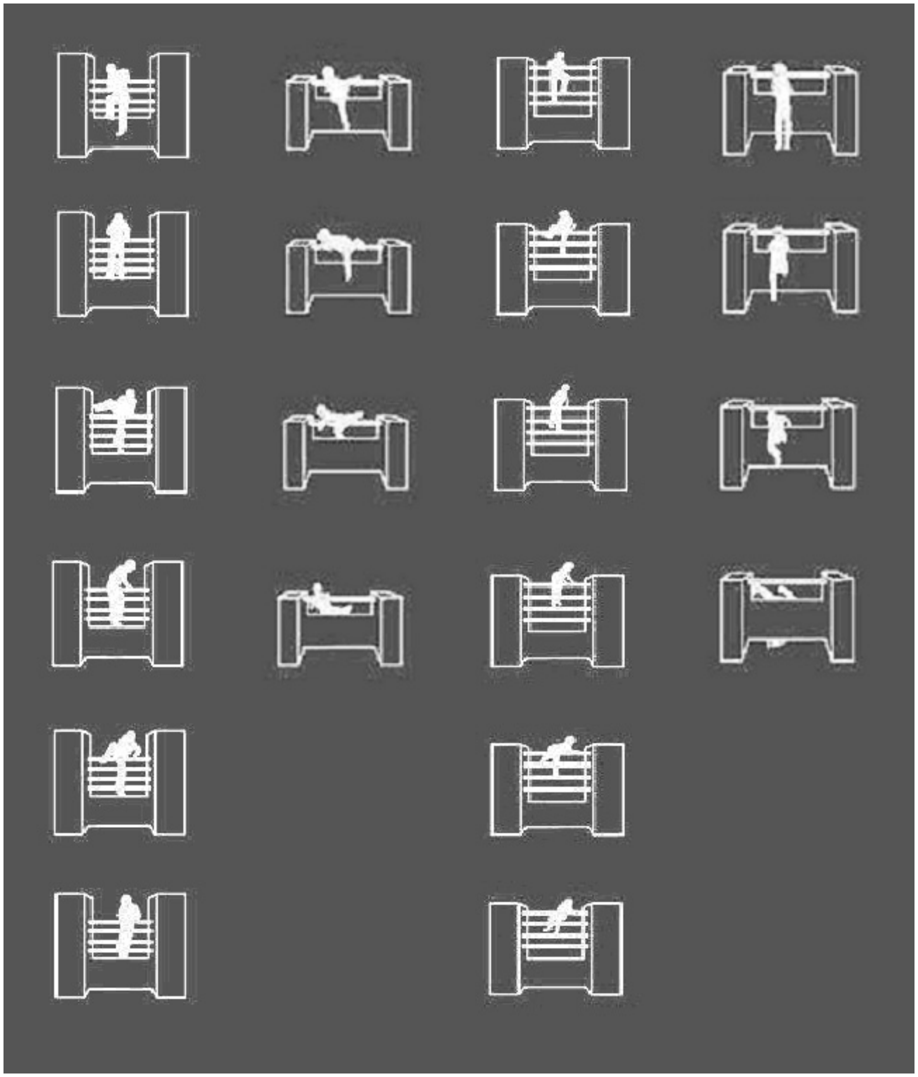


Figure 6 – Sequences of action modes. HOW (left column), HAW (left-center column), HOW to HAW (right-center column), and HUW (right column).

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.

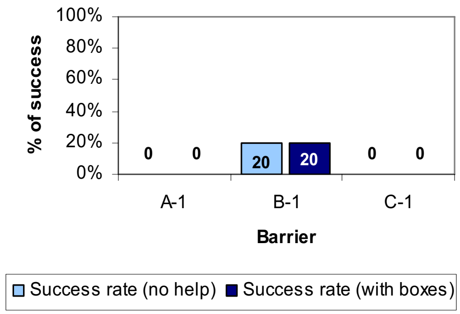


Figure 7 - Percentage of success in crossing the 3 barriers in Group 1.

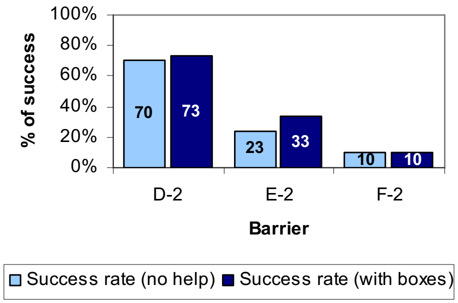


Figure 8 - Percentage of success in crossing the 3 barriers in Group 2.

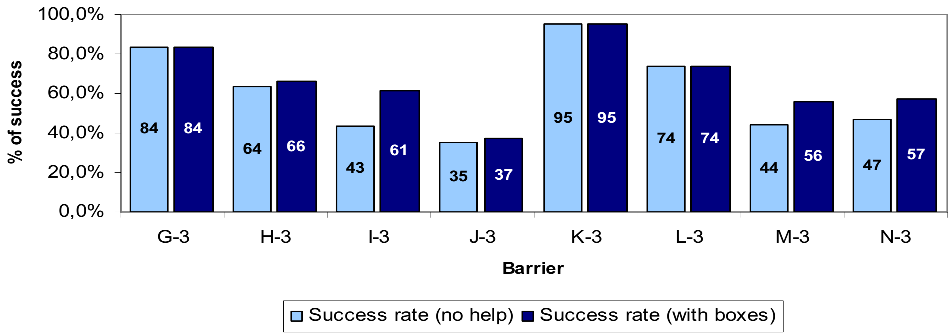


Figure 9 - Percentage of success in crossing the 8 barriers in Group 3.

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).

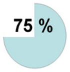
Figure 10 – Friends can encourage and help to cross a barrier.

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

No children in the age group crossed this barrier

Up to 25% of the children crossed this barrier

Between 25% and 50% of the children crossed this barrier



Between 50% and 75% of the children crossed this barrier

Between 75% and 99% of the children crossed this barrier

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.

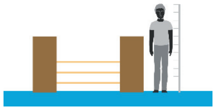
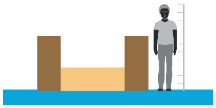
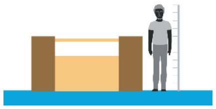
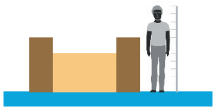
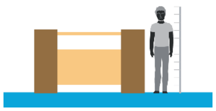
Barrier (reference child 1,10m tall)	Age (months)	Success	Barrier (reference child 1,10m tall)	Age (months)	Success
 A-1	9-18	0 %	 D-2	18-36	75 %
 B-1	9-18	25 %	 E-2	18-36	25 %
 C-1	9-18	0 %	 F-2	18-36	25 %

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

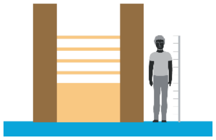
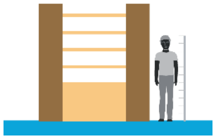
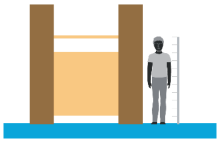
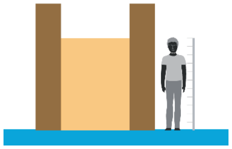
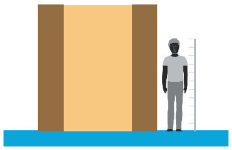
Barrier (reference child 1,10m tall)	Age (months)	Success	Barrier (reference child 1,10m tall)	Age (months)	Success
 G-3	36-48	75 %	 K-3	36-48	100 %
	48-60	50 %		48-60	100 %
	60-72	100 %		60-72	100 %
	> 72	100 %		> 72	100 %
 H-3	36-48	25 %	 L-3	36-48	50 %
	48-60	75 %		48-60	100 %
	60-72	100 %		60-72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

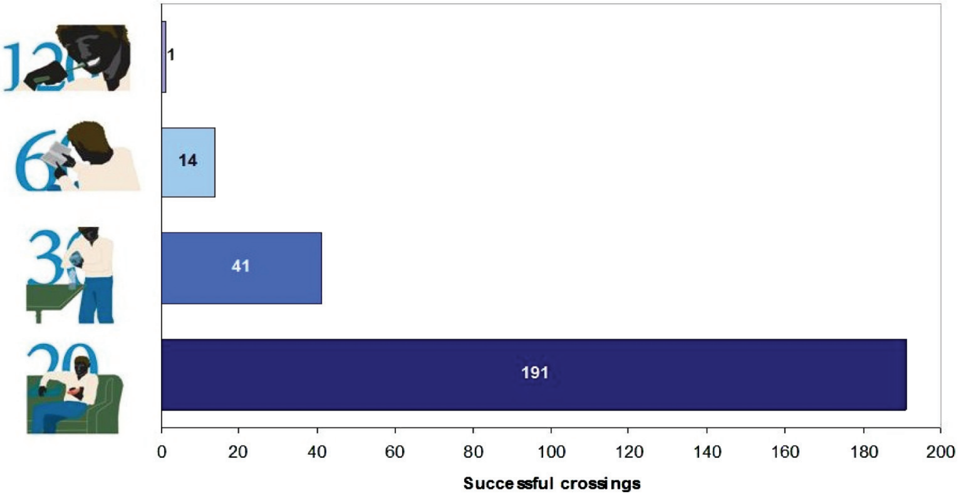


Figure 11 - Successful crossings by time category.

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.

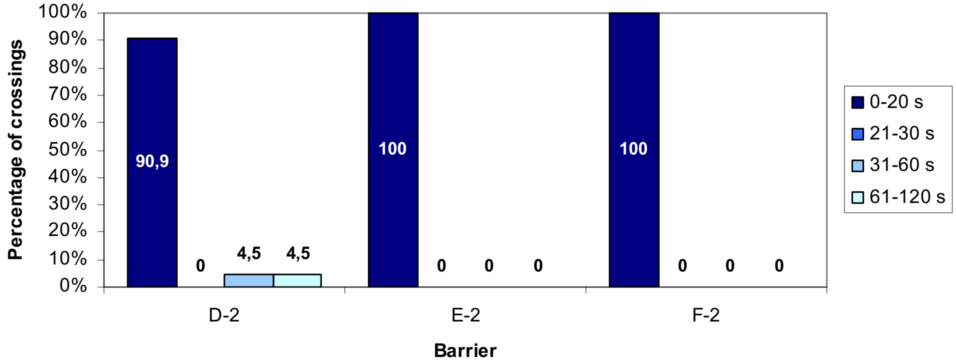


Figure 12 - Percentage of crossings according to different time categories in Group 2.

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.

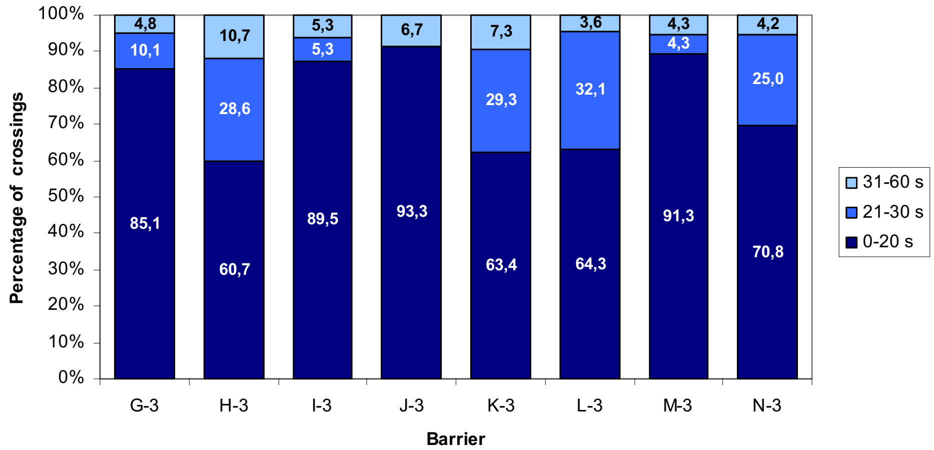


Figure 13 - Percentage of crossings according to different time categories in Group 3.

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.

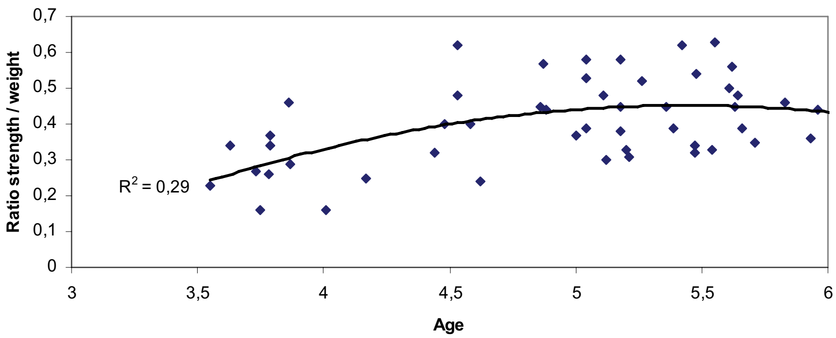


Figure 15 – Relationship between age and ratio strength/weight in group 3.

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.

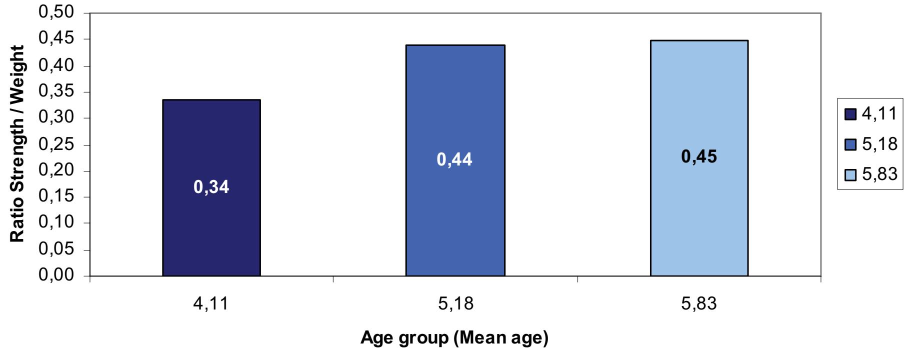


Figure 16 – Ratio strength/weight in 3 age subgroups of Group 3.

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.

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.

REFERENCES

AAP - American Academy of Pediatrics (2001). Fall from heights: windows, roofs, and balconies. *Pediatrics, 107*, 2, 1188-1191.

AAP – American Academy of Pediatrics (2003). Prevention of drowning in infants, children and adolescents. *Pediatrics, 112*, 437-439.

APSI (1998). Segurança nas piscinas. Goze o Verão sem sobressaltos. *Boletim da APSI*, Julho 1998.

Barreiros, J. & Silva, P. (1995). Hand size and grasping in infants. In B.G. Bardy, R. Bootsma and Y. Guiard (Eds.*), VIII*th *International Conference on Perception and Action* (pp.141-145). Lawrence Erlbaum Associates.

Berthental, B.L., & Campos, J.J. (1990). A systems approach to the organizing effects of self-produced locomotion during infancy (pp. 1-60). In C. Rovee-Collier (Ed.). *Advances in infancy research*, vol. 6. Norwood, NJ: Ablex

Brandt, I. (1984). Body measurements and proportions of preterm and full-term infants in the first six years - results of a longitudinal study. In J. Borms, R. Hauspie, A. Sand, C. Susanne, and M. Hebbelinck (Eds.), *Human growth and development* (pp. 253-269). New York: Plenum Press.

Crawley, T. (1996). Childhood injury: significance and prevention strategies. *Journal of Pediatric Nursing, 11*, 4, 225-232.

Culvenor, J.F. (2002). Design of childproof barriers to prevent falls from a height in public places. *The Proceeding of the XVI Annual International Occupational Ergonomics and Safety Conference*, 1-7.

Davies, B.N. (1990). The relationship of lean limb volume to performance in the handgrip and standing long jump tests in boys and girls, aged 11.6-13.2 years. *European Journal of Applied Physiology, 52*, 111-114.

De Ste Croix, M. (2007). Advances in paediatric strength assessment: changing our perspective on strength development. *Journal of Sports Science and Medicine, 6*, 292-304.

Gallahue, D.A. (1989). *Understanding motor development: infants, children, adolescents* (2nd Ed.). Indianapolis: Benchmark Press.

CEN Report (1999). *Child Safety – Risk assessment and design solutions.* Stockholm: SIS Forlag AB.

Gibson, E.J. (1969). P*rinciples of Perceptual Learning and Development.* New York: Appleton Century Crofts.

Gibson, E.J., & Pick, A.D. (2000). An *ecological approach to perceptual learning and development.* Oxford: Oxford University Press, Inc.

Gibson, E.J., & Walk, R.B. (1960). The visual cliff. *Scientific American, 4*, 67-71.

Greenfield, C. (2004). Can run, play on bikes, jump the zoom slide, and play on the swings': exploring the value of outdoor play. *Australian Journal of Early Childhood, 29*, 1-5.

Haschke, F., van't Hof, M. & Euro Study Group (2000). Euro-Growth References for length, weight, and body circumferences. *Journal of Pediatric Gastroenterology and Nutrition, 31*, 1, S14-S38.

Haywood, K.M., & Getchell, N. (2001). *Life Span Motor Development (3rd Ed.)*. Champaign, IL: Human Kinetics.

Held, R., & Hein, A. (1963). Movement-produced stimulation in the development of visually guided behaviour. *Journal of Comparative and Physiological Psychology*, 56, 872-876.

ISAK (2006). *International Standards for Anthropometric Assessment*. Sydney: UNSW Press.

Istre, G.R., McCoy, M.A., Stowe, M., Davies, K., Zane, D., Anderson, R.J. & Wiebe, R. (2003). Childhood injuries due to falls from apartment balconies and windows. *Injury Prevention, 9*, 349-352.

Jordan, J. R.(1988). El lactante de 0 a 2 anos: Antropometria y crecimiento. In M. Cusminsky, E. M. Moreno, e E. N. Suarezojeda (Eds.), *Crecimiento y desarrollo. Hechos y tendências* (pp. 184-209). Washington: Organizacion Panamericana de la Salud.

Kim, A., Wang, M.Y., Griffith, P.M., Summers, S., & Levy, M. L. (2000). Analysis of pediatrics head injuries from falls*. Neurosurgical Focus, 8*, 1, art 3.

Lallier, M., Bouchard, S., St-Vil, D., Dupont, J., & Tucci, M. (1999). Falls from heights among children: a retrospective review. *Journal of Pediatric Surgery, 34*, 7, 1060-1063.

Lee, D.N., & Aronson, E. (1974). Visual proprioceptive control of standing in human infants. *Perception & Psychophysics, 15*, 529-532.

Little, H. (2006). Children's risk-taking behaviour: implications for early childhood policy and practice. *International Journal of Early Years Education, 14*, 141-154.

Mayer, L., Meuli, M., Lips, U., & Frey, B. (2006). The silent epidemic of falls from buildings: analysis of risk factors. *Pediatric Surgery Int, 22*, 743-748.

McDowell, M.A., Fryar, C.D., Hirsch, R. & Ogden, C.L. (2005). Anthropometric Reference Data for Children and Adults: U.S. Population, 1999-2002. *Advance Data from Vital and Health Statistics, 361*, July 7. http://www.cdc.gov/nchs/about/major/nhanes/advancedatas.htm

Menezes, H., & Eloy, S. (2007). Segurança das crianças nos ambientes construídos. *Livro de Actas do 3º Congresso de Construção 2007* (doc C-107). Universidade de Coimbra.

Morrongiello, B.A. (2005). Caregiver supervision and child-injury risk: I. Issues in defining and measuring supervision; II. Findings and directions for future research. *Journal of Pediatric Psychology, 30*, 536-552.

Morrongiello, B.A., & Major, K. (2002). Influence of safety gear on parental perceptions of injury risk and tolerance for children's risk taking. *Injury Prevention, 8*, 27-31.

Morrongiello, B.A., Walpole, B., & Lasenby, J. (2007). Understanding children's injury-risk behavior: Wearing safety gear can lead to increased risk taking. *Accident Analysis and Prevention. 39*, 3, 618-623.

National Institute of Child Health and Human Development (2001). NIH News Release, July 2, 2001.

Newell, K.M. (1986). Constraints on the development of coordination. In M. Wade and H.T.A. Whiting

(Eds.), *Motor development in children: Aspects of coordination and control* (pp 341-360). Dordrecht, the Netherlands: Martinus Nijhoff.

Nixon, J., Pearn, J., & Petrie, G. (1979). Childproof safety barriers. *Australian Paediatric Journal, 15*, 260-262.

NP EN 1176-1 (1998). *Equipamentos para espaços de jogo e recreio. Parte 1: Requisitos gerais de segurança e métodos de ensaio*. Instituto Português da Qualidade.

Payne, V.G., & Isaacs, L.D. (1995). *Human Motor Development. A Lifespan Approach* (3ª Ed.). Mountain View, California: Mayfield Publishing Company.

Peterson, L., Ewigman, B., & Kivlahan, C. (1993). Judgements regarding appropriate child supervision to prevent injury: the role of environmental risk and child age. *Child Development, 64*, 934-950.

Piper, M.C., & Darrah, J. (1994). *Motor assessment of the developing infant.* Philadelphia: Saunders

Pressley, J.C., & Barlow, B. (2005). Child and adolescent injury as a result of falls from buildings and structures. *Injury Prevention, 11*, 267-273.

Rabinovich B.A., Lerner N.D. & Huey R.W. (1994). Young children's ability to climb fences. *Human Factors, 36*,4, 733-744.

Riley, J.E., Roys, M.S., & Cayless, S.M. (1998). Initial assessment of children's ability to climb stair guarding. *The Journal of the Royal Society for the Promotion of Health, 118*, 6, 331-337.

Roche, A. & Malina, R. (1983). *Manual of Physical Status and Performance in Childhood*, vol. 1-A, 1-B e 2. New York: Plenum Press.

Saluja, G., Brenner, R., Morrongiello, B.A., Haynie, D., Rivera, M., & Cheng, T. (2004). The role of supervision in child injury risk: definition, conceptual and measurement issues. *Injury Control and Safety Promotion, 11*, 17-22.

Sieben, R.L., Leavitt, J.D., & French, J.H. (1971). Falls as childhood accidents: an increasing urban risk. *Pediatrics, 47*, 886-892.

Sparks, J. W. (1992). Physiology of growth. In R. A. Polin and W. W. Fox (Eds.), *Fetal and neonatal physiology* (pp. 199-204). Philadelphia: W.B. Saunders Company.

Spiegel, C.N. & Lindaman, F.C. (1977). Children can't fly: a program to prevent childhood morbidity and mortality from window falls. *American Journal of Public Health, 67*, 12, 1143-1147.

Stephenson, E. (1988). *The Silent and Inviting Trap*. The Building Official and Code Administrator.

Svejda, M., & Schmidt, D. (1979). The role of self produced locomotion on the onset of fear of heights on the visual cliff. *Book of abstracts of the Society for Research in Child Development*. San Francisco.

Tanner, J.M. (1962). *Growth at adolescence* (2.ª ed.). Oxford: Blackwell Scientific Publications.

Thelen, E., Ulrich, B.D., & Jensen, J.L. (1989). The developmental origins of locomotion. In M.H. Woolacott and A. Shumway-Cook (Eds.), *Development of posture and gait across the life span* (pp. 25-47). Columbia: University of South Carolina Press.

van Herrewegen, J., Molenbroek, J., & Goosens, H. (2004). *Children's Climbing Skills*. R &T project to identify what products children can climb on and how they use support points while climbing these products - Part 1. ANEC.

Vaughan, V.C., McKay, R.J., & Behrman, R.E. (1979). *Textbook of pediatrics.* Philadelphia: W. B. Saunders Company.

Vieira, F. & Fragoso, I (in press). *Reavaliação Antropométrica da População Infantil de Lisboa. Tendência Decenal*. Lisboa: Imprensa Nacional.

Vieira, F. & Fragoso, I. (2006). *Morfologia e Crescimento*. Lisboa: Edições FMH.

Vish, N.L., Powell, E.C., Wiltsek, D., & Sheehan, K.M. (2005). Pediatric window falls: not just a problem for children in high rises. *Injury Prevention, 11*, 300-303.

Wang, M.Y., Kim, K.A., Griffith, P.M., Summers, S., McComb, J.G., Levy, M.L., & Mahour, G.H. (2001).

Injuries from falls in the pediatric population: an analysis of 729 cases. *Journal of Pediatric Surgery, 36*, 10, 1528-1534.

WHO, *Child Growth Charts* - http://www.who.int/childgrowth/en/

Williams, H.G. (1983). *Perceptual and motor development.* Englewood Cliffs, NJ: Prentice-Hall.