

## **Arborists' harness for work at height and fall protection**

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**Abstract.** Arborists are cutting branches of trees. Work methods and work positioning systems were reviewed to increase the fall protection without increase the burden of the work. Experimental evaluations were done to measure the efficiency, the reliability and the user-friendliness of several individual work positioning systems and several fall arrest systems. The efficiency and the reliability were evaluated by mechanical tests done in laboratory. The user-friendliness evaluations by arborists were performed in controlled environment in urban forests and parks. Their psychophysical perceptions and their opinions were collected with questionnaires and semi-directed interviews. For harness, 5 sub protocols were executed. The sit harness was the reference and the full body harness identified is as comfortable as the sit harness with an increase in safety and comfort.

**Keywords.** arborists, harness, evaluation, fall arrest, work at height

### **1. Context**

Arborists (tree trimmers) are cutting branches of trees for the safety of humans and equipment, esthetic considerations and the health of the trees. They are using cutters and chain saws. For climbing, they are using ladders, personal aerial work platforms PAWP or ropes and systems similar to mountaineering equipment. In Quebec, arboriculture employers have an insurance fee of 20,60\$ per 100\$ of salary (1999), while the average rate was 2,47\$ in 1998. The rate in arboriculture illustrates the high incidence of occupational injuries.

In 2001, the province of Quebec (Canada) updated its industrial and construction OSH regulations making the full body harness mandatory for fall protection and reinforcing to use of fall protection. Arborists were reluctant to the change while the International Society for Arboriculture ISA makes fall protection and full body harness mandatory during the international competitions. At the same time, several attempts to improve climbing and work techniques and equipment were done by individuals; those individuals were adapting equipment used in sport, climbing, mountaineering, speleology, and rescue. Most equipment was covered by standards with a specific scope excluding other uses. They are not necessarily transferable to other field of use. The political and technical contexts required a systemic assessment of work positioning and fall arrest systems for arborists. As in any work at heights, fall protection is required. The global objective of the project was the reduction of fall hazards or of fall risks. Work methods and work positioning systems were reviewed

to increase the fall protection without increase the burden of the work (Arteau et al 2007).

## **2. General methodology**

Experimental evaluations were done to measure the efficiency, the reliability and the user-friendliness of several individual work positioning systems and several fall arrest systems. The efficiency and the reliability were evaluated by mechanical tests done in laboratory. The user-friendliness evaluations were performed in controlled environment in urban forests and parks of the city of Montreal. The psychophysical perceptions (effort, mobility, and global safety), physiological reactions (heart rate) and their opinions with questionnaires and semi-directed interviews were collected. The project was divided in 4 parts: 1) attachment link in personal aerial work platform PAWP, 2) harness, 3) mechanical tests of mountaineering components according to industrial safety standards which are more stringent and finally 4) with the selected harness in (2) and with the acceptable components in (3), work access, work positioning and fall arrest systems were evaluated in controlled environments made of several different trees. The results for harness (2) are presented. Ten professional arborists were volunteers for the project; 3 from the municipal sector, 3 from the utility sector and 4 from the residential and commercial sector. They varied in experience, 3 to 22 years (avg. 12,1 years) in the arboriculture trade. They also varied in age (min. 28; avg. 35,5; max 45), anthropometry (height cm: min. 165; avg. 174; max. 183) (mass kg: min. 65; avg. 75; max. 100) and training. They were either self-employee or employee of large companies.

## **3. Methodology for harness designed for arborists**

The selection of a full-body harness was done in 5 steps:

1. The selection of shoulder strap configuration and material,
2. Validation of full-body harness while working in an aerial device,
3. Validation of full-body harness while working in a tree using rope climbing methods and using spur climbing methods,
4. Validation of full-body harness while working in a tree, with tools attached to the belt, using a combination of rope climbing and spur climbing methods;
5. Long term validation of the selected harness.

The arborists gave their appreciation on questionnaire with a visual analog scale. All data were analyzed with an ANOVA.

## **4. Results and discussion**

### *4.1 The selection of shoulder strap configuration and material*

All harnesses were from the same manufacturer and were complying with the CAN/CSA Z259.10.-M90 standard. Four combinations of webbing and configuration were evaluated (Table1); all could provide additional comfort and facilitate acceptance and wearing of the harness. The experimental plan was a 2×2: webbing material (rigid or elastic) × configuration (V or X).

**Table 1.** *Harness material and configuration of webbings.*

1	2	3	4
Crossed X Rigid	Crossed X Extensible	Floating double V Rigid	Floating double V Extensible
			
			

Five exercises were performed by the subjects to help them to better appreciate the differences in materials and configurations (Table 2). The variables are listed in Table 3.

**Table 2.** *Tasks for harness webbing configuration*

1	2	3	4	5
Simultaneous flexion of shoulders	Torso flexion	Torso abduction and adduction to the right	Climb a vertical ladder with 1 over 2 runs missing	Knees flexion (squat)
				

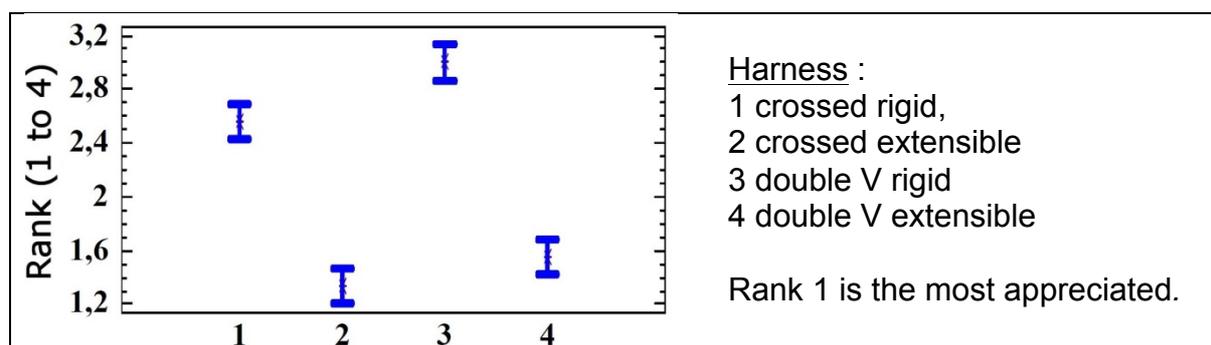
**Table 3.** *Variables*

Independent variables	Dependent variables
<ul style="list-style-type: none"> <li>• Tasks</li> <li>• Configurations and material</li> </ul>	<ul style="list-style-type: none"> <li>• Nuisance right shoulder</li> <li>• Nuisance left shoulder</li> <li>• Nuisance right hip</li> <li>• Nuisance left hip</li> <li>• Global appreciation</li> </ul>

After each task, the arborists self-answered a questionnaire. At the end, arborists ranked the harness 1st, 2nd, 3rd and 4th choice. The extensible webbing (2 and 4) was preferred and the configuration has nearly no influence (Figure 1). With the rigid webbing, the crossed configuration is preferred.

The extensible webbing is useful in asymmetrical movements. The double V (3 and 4) has theoretically the advantage to auto-adjust at the shoulder in asymmetrical movements. Analysis shows most arborists did not preferred the double V. In contrary, the complexity for donning and adjusting is the negative point of the floating

double V configuration because of the too great mobility. Data had shown that the elastic crossed “X” combination was preferred by the subjects.



**Figure 1.** Ranks for harness – webbing and configuration

#### 4.2 Validation of full-body harness while working in an aerial device

The use of fall arrest equipment is mandatory in aerial work platforms by regulations and its need well demonstrated (Arteau 1998). Arborists' harnesses are globally equally or better appreciated than the standard harness. The harness with thigh straps seems to be the best choice. The same harness could be used in an aerial platform and in the tree.

#### 4.3 Validation of full-body harness while working in a tree using rope climbing methods and using spur climbing methods

The experimental plan is a  $2 \times 2$  (belt vs harness  $\times$  thigh straps vs rigid buttock support) (Table 4). The belt with thigh straps was the standard equipment for arborists.

**Table 4.** Harnesses for working in a tree using rope and spur climbing methods

1	2	3	4
Belt with thigh straps (sit harness)	Belt with a rigid buttock support	Harness with thigh straps	Harness with a rigid buttock support
			

The tasks were two circuits with several stations on 2 different trees. All stations were selected in order to force specific gestures. At each station, a questionnaire was filled. The arborists were familiar with these circuits because they are similar with the circuits used during ISA competitions (Figures 2 and 3).

The harness with thigh straps is the most appreciated and is as comfortable as a belt. The shoulder straps of the harness support loads fixed at the belt increasing the comfort. Without the rigid buttock support, the harness is lighter and giving more

mobility (Figure 4). The harness no.3 was ranked first by 7 (rope) and 9 (spurs) arborists

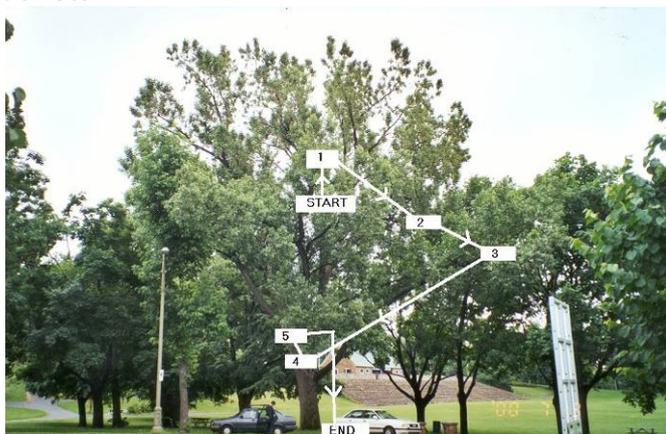


Figure 2. Circuit climbing with a rope

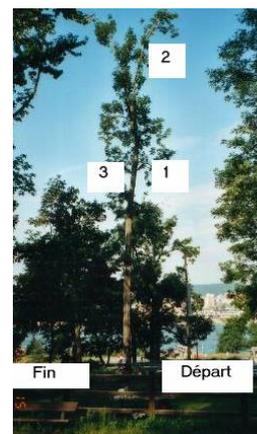


Figure 3. Circuit climbing with spurs

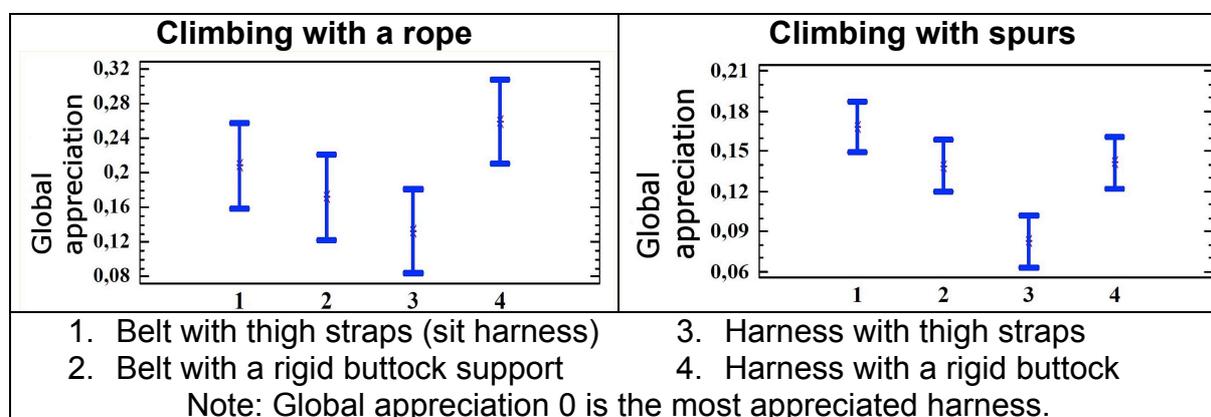


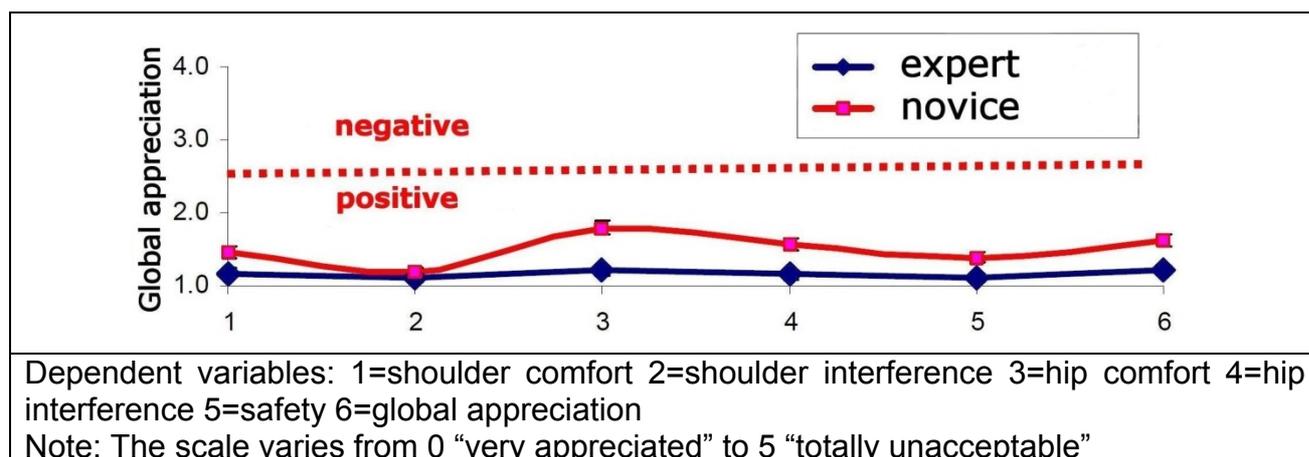
Figure 4. Harness global appreciation – Climbing with rope and climbing with spurs.

#### 4.4 Validation of full-body harness while working in a tree, with tools attached to the belt, using a combination of rope climbing and spurs climbing methods

This step was a mixture of 4.1 and 4.3. The results confirm the preference for the harness with crossed extensible straps over a belt and a harness with the double V configuration.

#### 4.5 Long term validation of the selected harness

After the 4 first protocols, the harness with crossed webbings was identified. But are the 10 volunteer arborists somehow influenced by the research team? Then a three month evaluation was done with the expert subjects (participating in the project) and with novice arborists (none participating in the project). A questionnaire was developed to be self-answered 4 times per day. It was similar to a log-book for production control. The data were collected and analyzed. No significant differences between both groups: they appreciated the harness (Figure 5). Arborists' harnesses are equally or better appreciated than the standard sit harness. The harness with thigh straps seems to be the best choice and could be used in an aerial platform and in the tree.



**Figure 5.** Long term appreciation – expert and novice.

## 5. Conclusion and practical tools.

The sit harness was the reference and the full body harness identified is as comfortable as the sit harness with an increase of safety. In 2001, the change from sit harness to full body harness and more complex systems was a significant evolution for arborists. In 2014, they are still using these systems because all questions from arborists were answered by a systemic and global approach (Desjardins-David, I. and Arteau, J. 2011).

Tools and aids to workers and employers were produced. A detailed specification for arborist’s harness was developed for the manufacturers (CSST 2002). Then a joint committee had written a guide on safe work practices (CSST 2009).

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