

# PROJECT "SOSPESI (SUSPENDED)"

Reports relative to the first phase

September 2012

## Introduction

For the past two years C.A.M.P. and the Università degli Studi di Milano Bicocca have been collaborating in the research project "SOSPESI (SUSPENDED)"\* to study the possible onset of Suspension Trauma (ST) in workers and climbers that use a harness.

The first phase of testing has been completed and the first part of the analyzed data has already led to some conclusions that can be of great interest to all workers in height and mountaineers.

## The research team

The project "SOSPESI (SUSPENDED)" is conducted by a team of eight researchers at the Ambulatorio di Fisiologia Clinica dello Sport (Sports Clinic of Human Physiology) at the Università degli Studi di Milano Bicocca ([www.fisiologiaclinica.medicina.unimib.it](http://www.fisiologiaclinica.medicina.unimib.it)).

The team is composed of:

Prof. Giuseppe Miserochi, Professor of Human Physiology  
Dr. Francesca Lanfranconi, Research Fellow in Human Physiology  
Dr. Luca Pollastri, Specializing in sports medicine  
Dr. Manuela Bartesaghi, Specializing in sports medicine  
Cinzia Molteni, Graduate student in Medicine and Surgery  
Hayley Vergani, Graduate student in Medicine and Surgery  
Dr. Massimiliano Novarina, Graduate in Physical Education, assistant  
Dr. Leila Meroi, Psychologist, assistant

\* The other sponsors of the research project are: "Servizi e Sistemi", "Geoneer Group".



## The project

The idea to conduct this research project is attributable to the 3rd conference on "Lavoro e Montagna, insieme per l'alta sicurezza" (Work and Mountain, united for high security)(Lecco, 2008) where it was discovered that a worker who uses a harness may incur peculiar medical risks but still relatively little is known of the pathophysiological characteristics. The research project was aimed to study two major themes:

### 1. **Recognition of the risk of Suspension Trauma (HHS) for workers.**

Suspension trauma (ST) or Harness Hang Syndrome (HHS) is an entity whose true incidence is misunderstood, even though it has been well known since the 1960's as a result of an autopsy of pathologies not related to trauma in climbers and cavers that died in harness.

Neither the harness itself, nor the eventual trauma are the main cause of the fatal event. Instead, it appears to be linked to a lack of oxygen to vital organs (visceral multi hypoxia). The syncopal event (ie: a sudden and transient loss of consciousness) is the largest problem that the person suspended can experience and this problem carries the inherent risk of death if relief is not immediate.

Therefore, ST (Suspension Trauma) is an event that people using harness for work purposes should be aware of. In addition to the lack of knowledge of the clinical events related to what triggers ST and any environmental or physiological conditions that favor it, it's difficult to define possible guidelines for the rescue of those who remain suspended (RB Mortimer, 2011).

The use of humans for the experimental models is essential to verify the authenticity of the events related to ST, it implies ethical limits due to possible pathological events (even severe) in individuals subjected to the study (Seddon P, 2002). However, most authors suggest that the potential existence of ST needs to be studied on healthy volunteers that use harnesses in order to verify whether the syndrome is only a theoretical risk or a certainty that could warrant special legislation in the field of safety at work (Lee C, 2007; Seddon P, 2002).

### 2. **Does working in a harness have characteristics attributable to heavy industry work?**

Workers who use a harness daily for many hours (rope access workers, tree-climbers, rescuers, mountain guides, etc...) seem to have an increased risk of thromboembolic events despite being aware and active while being suspended by rope (Pisati G, 2007).

Certain environmental conditions and/or adverse physiological conditions (hypothermia and dehydration) may also predispose the worker, in addition to the ST, to other adverse clinical events, especially if there is concomitant pathology not known to the employee. The identification of predisposing pathologies, and the prevention of adverse physiological and environmental conditions, would allow an important characterization of workers suitable for this type of work and the specific technical training to be performed.



The characteristic of energy consumption of work in a harness is not quantified. The levels of concentration and attention necessary for the performance of the person have not been analyzed. Considering that fatigue and concentration decay could cause an increased risk of ST, it is important to check whether working in harness may have characteristics attributable to heavy industry work.

### The aim

The aim of the research project "SOSPESI (SUSPENDED)" was therefore to:

- check the incidence of ST during suspension in a harness;
- check the incidence of pathophysiological events that may lead to a syncopal event during suspension;
- assess the presence of any ST predisposing factors;
- analyse possible indications for a functional assessment test that the worker in a harness should undergo to verify the state of health and susceptibility to incur ST;
- verify the characteristics of energy consumption, attention and concentration when working in a harness.

### Materials and methods

40 healthy individuals have participated in the study (35 men and 5 women), the characteristics of age and anthropometry are shown in Table 1. Please note that the average values for the group of men are characteristic of the person using the 'harness (39 years old, 75 kg), while the interval of age, weight and body mass index ( $BMI = \text{weight} / \text{height}^2$ ) include individuals with age and anthropometric characteristics that are very different. In fact, a user of a harness may also have a very petite physique below 55 kg or vice versa, be robust (more than 100 kg), and also rarely, but not exceptionally, be over 60 years of age.

	Age	Weight	Height	BMI	% fat
	years	kg	m		
<b>MAN (35)</b>					
average	38.9	75.4	1.76	24.3	11.7
st dev	8.3	11.7	0.07	3.0	4.5
<b>WOMEN (5)</b>					
average	28.0	54.4	1.66	19.7	13.6
st dev	8.2	5.2	0.06	0.8	1.9
<b>range</b>	22-59	48-115	1.6-1.9	18-33	6-24

Table 1

All project participants have signed a consent form to participate in the project. The research project was approved by the Ethics Committee of the Università degli Studi di Milano Bicocca and meets the guidelines of the Helsinki Declaration in relation to experimentation performed on humans.

The 35 men were divided into three groups: people who use the harness for work and / or climbers (n = 16), aerobic athletes (bottom and middle distance) (n = 11) and sedentaries (n = 8) both without experience in the use of a harness. Each individual has been subjected to a total of 4 evaluation tests divided into 4 sessions on different days: a baseline evaluation with cardiopulmonary exercise testing in order to determine the state of health and the level of aerobic training (Figure 1a); a passive suspension test (described below in detail) (Figure 1b), a simulation test of work activity on a special gym rope reconstructed in the laboratory, a work simulation test with correction factors imposed by the researcher (hydration and use of the posterior kinetic chain exercises) (Figure 1c).





Researched variables:

- *oxygen consumption ( $VO_2$ )*. The determination of  $VO_2$  consumption is considered one of the main variables for the overall assessment of the functions of the muscles, the cardiovascular system and the respiratory system. This determination was made possible through the use of a metabolimeter with the possibility of evaluating the gas exchange variables measured breath by breath.
- *muscle and brain extraction capacity of  $O_2$* . Over the past few years, for non-invasive functional assessment methods of the oxidative metabolism at the tissue level, the Near Infrared Spectroscopy or the NIRS method has been introduced. This method has allowed us to evaluate, in this research project, the supply and use of  $O_2$  by the muscle and brain under conditions of suspension. The NIRS probe was placed on the vastus lateralis muscle of the quadriceps and in the front for the brain.
- *heart rate*. Measured with a continuous 12-lead ECG (electrocardiogram) for all tests carried out.
- *arterial saturation of  $O_2$* . Measured continuous pulse oximetry on the finger.
- *systolic and diastolic blood pressure*. Measured by sphygmomanometer.
- *assessment of the subjective perception of fatigue*. Measured by the Borg Scale of Perceived Exertion.
- *tests for assessing possible cerebral hypoxia, the capacity of attention, memory, concentration and inhibition*. A series of neurological tests have been carried out, including Frontal Battery Assessment and Mini Mental State Examination.

### Suspension test.

The test of passive suspension was conducted by carrying out a controlled suspension (Figure 1b): the individual's lower limbs were completely motionless while there was the possibility of using the stabilizing muscles of the entire vertebral column.

In addition, it has been decided to use a safety harness with the best characteristics of comfort available on the market (CAMP Safety Golden Top Evo Alu art.941.02).

The suspension was made on the ventral attachment point (Figure 2).

It was decided to perform this type of experimental approach because, as indicated by the Ethics Committee, the research participants were placed in the least disadvantageous conditions relative to comfort and it ensured the possibility of rescue by the researchers in case of a syncopal event, compared to a normal economic anti-fall belt.

The orientation of the body and the comfort of the suspended person, determined mainly by the individual characteristics and suitability of the harness from the engagement position to the system seem to in fact, play an equally important role on the consequences of the suspension (Hsiao H, 2007; Turner NL, 2008).

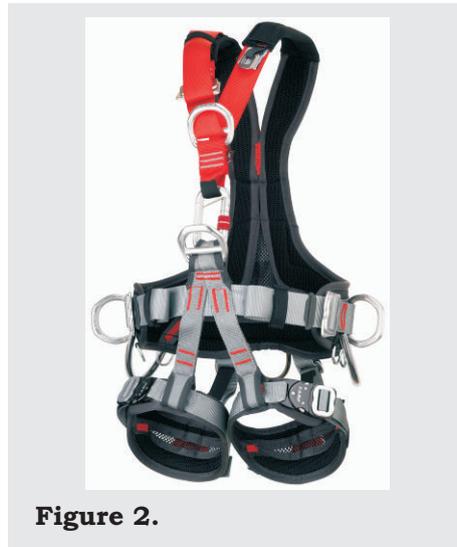


Figure 2.

Interruption criteria of the test were: signs or symptoms of Presyncopal (pallor, nausea, hot flushes), systolic blood pressure decreased by 20 mmHg compared to baseline condition, diastolic blood pressure decreased by 10 mmHg compared to baseline condition, FC increased by 20 bpm compared to baseline value, FC decreased by more than 10 bpm compared to the baseline condition; brain desaturation following the NIRS tracing.

### Partial results of the suspension test

The average suspension time was approximately 29 minutes. There is no statistically significant difference between groups of experienced individuals in using a harness and groups of unexperienced users, with respect to the possibility of experiencing a syncopal event (Figure 3). No one was suspended for more than 60 minutes. In each group there exists a great heterogeneity with respect to tolerance to suspension time: some individuals remained suspended for a few minutes while others for more than 50.

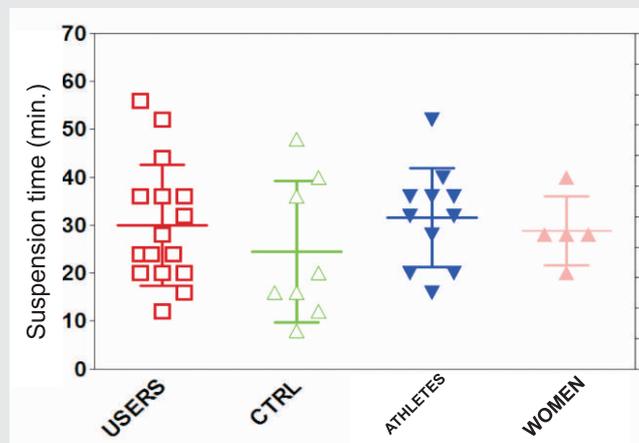
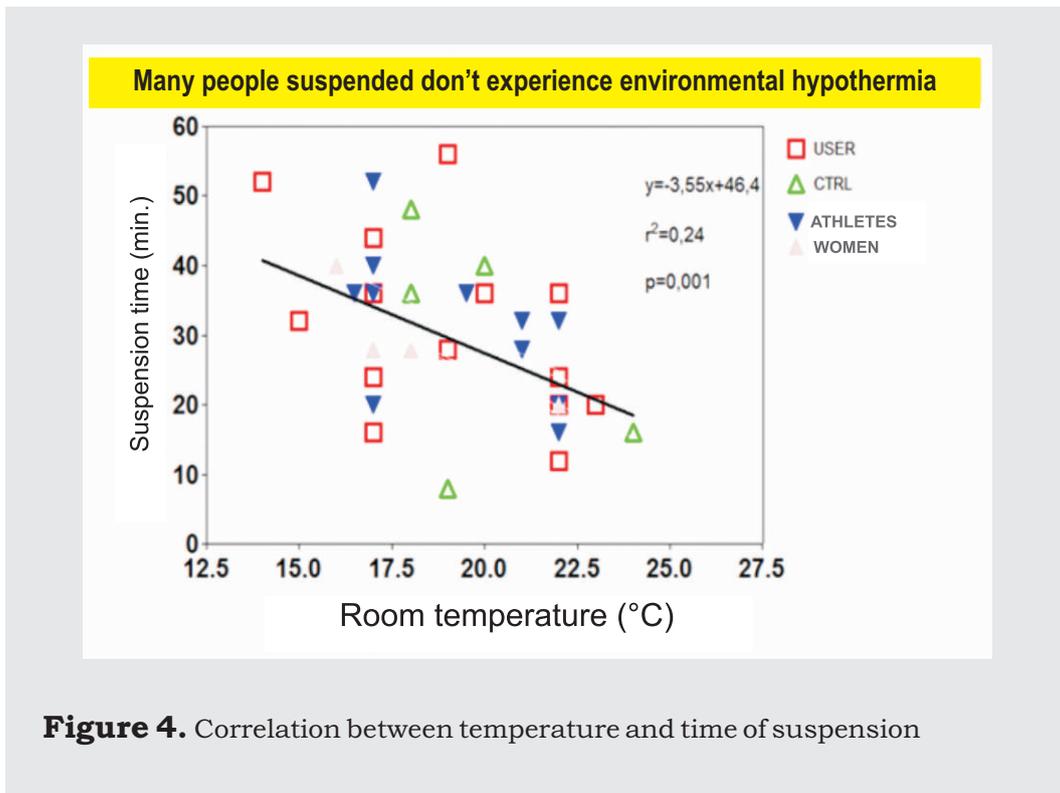


Figure 3 Suspension time in the 4 groups studied. USERS = experienced in using harnesses. CTRL = sedentaries.

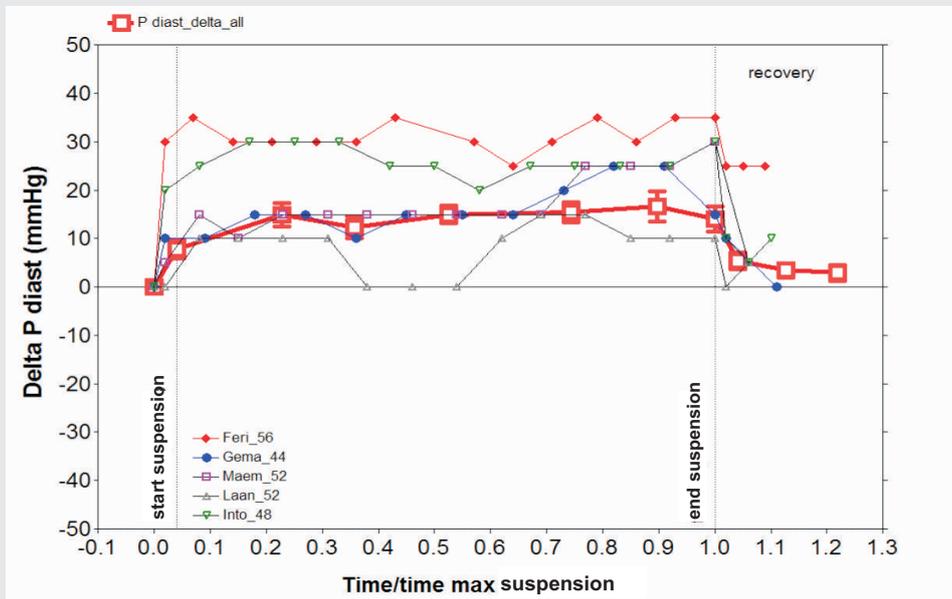
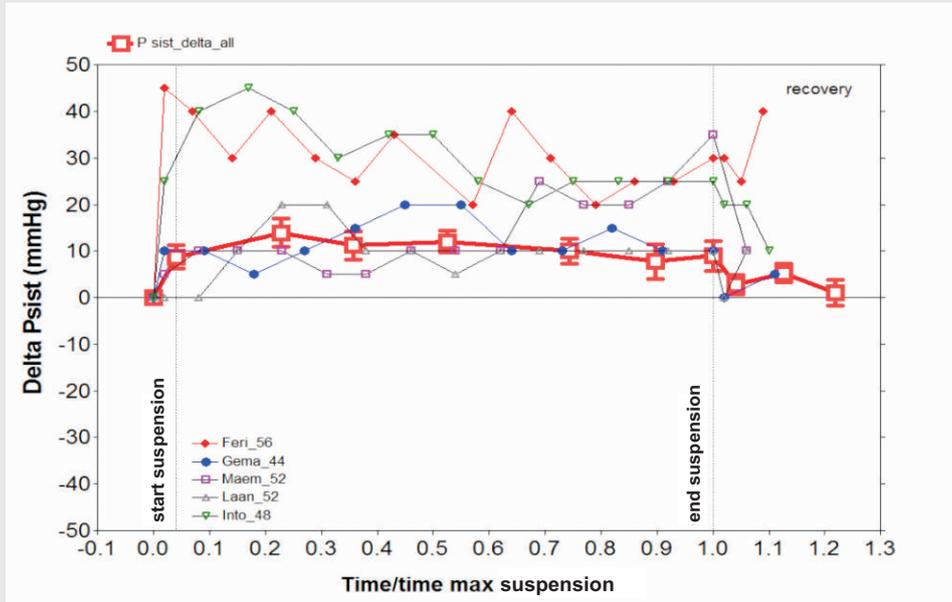


The room temperature affected the time of suspension: higher temperatures decrease the suspension time (Figure 4). People suspended at room temperature below 18 ° C were asked if they felt cold and, it was observed that there was a reduction in the criticality relative to the hypothermic factor, as only 20% claimed to having been aware of the low temperature in the clinic.



There is a characteristic increase in the values of heart rate and systolic-diastolic blood pressure during the suspension test with respect to the value found in baseline conditions on the ground. In Figure 5a, the average values of the whole population researched (red line) relative to the systolic pressure are shown. The values of the 5 people who tolerated the suspension best are visible. In Figure 5b, the diastolic pressure values are similarly shown. Two individuals showed severe systolic hypertensive values (> 180 mmHg) for which it was necessary to stop the test, and as much as 25% of the total tests were interrupted due to severe diastolic hypertension values(> 110 mmHg). This finding does not constitute a cause for concern in young and healthy individuals, but in the presence of a concomitant cardiovascular pathology, it can be dangerous.

Concerning the extraction capacity of O<sub>2</sub> at the tissue level through the NIRS, there is no evidence that brain hypoxia is the trigger for a syncopal event.



**Figure 5** a) b) Change in systolic-diastolic pressure during the suspension test with respect to the baseline ground value.

## Conclusions and future prospects

The data analysis is still in progress (especially with regard to simulation tests of work activity), but from what we have seen until now, it is evident that through the functional evaluation proposed, it is possible to characterize the events that can lead to a syncopal event in a harness and any possible risk factors for the individual worker. 10% of people participating in the project "SOSPESI (SUSPENDED)" experienced a syncopal event.

The data reported in this publication has already been brought forth in the annual conference of Medicina di Montagna a Trento (Mountain Medicine in Trento) (April 2012).

In October 2012 at the 4th conference on "Lavoro e Montagna, insieme per l'alta sicurezza" (Work and Mountain, united for high security) in Lecco, of which C.A.M.P. is a sponsor, the results of the entire first phase of the project "SOSPESI (SUSPENDED)" will be presented and followed by an open end discussion with experts in the field.

A scientific publication in an indexed medical journal to assess the impact of the findings from the project "SOSPESI (SUSPENDED)" on the scientific community will also be proposed.

The second phase of the project has already begun and, taking into account the results of the first stage, we are carrying out comparative tests of new prototypes of harnesses specially developed to minimize the impact of suspension on the human body.

C.A.M.P. is confident that at the end of the project "SOSPESI (SUSPENDED)", there will be a possibility to present new solutions and specific products specially designed to address this matter.

All of the foregoing is not intended as a disincentive to carry out work in a harness, but rather, as an aid in worker training through increased awareness of the risks of suspension combined with the expertise and instruction on technical movements.



**UNIVERSITA' DEGLI STUDI DI  
MILANO BICOCCA**  
**FACOLTA' DI MEDICINA E CHIRURGIA**  
**Dipartimento di Medicina  
Sperimentale**  
Via Cadore, 48 - 20052 Monza (MI)  
Tel. +39-0264488309



is a brand owned by **CAMP** SPA  
**CONCEZIONE ARTICOLI MONTAGNA PREMANA**

Via Roma 23,  
23834 Premana (LC)  
ITALY

Tel. +39 0341 890117  
Fax +39 0341 818010

[www.camp.it](http://www.camp.it)  
[contact@camp.it](mailto:contact@camp.it)