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THE CHALLENGE OF HEALTH AND SAFETY PROMOTION AT WORK:
BALANCE TRAINING FOR FITNESS AND FALLS PREVENTION AMONG SWEDISH CONSTRUCTION WORKERS

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OCCUPATIONAL RISKS IN BUILDING AND CONSTRUCTION WORK

The occupational groups in the building and construction industry retain top positions in national work injury statistics, mainly through traumatic and musculo-skeletal injury and disease.

The latest report on occupational risks in Sweden (AFA 2006) show that building and construction workers run risks of sustaing severe and permanently disabling work-related injuries several times higher than the labour-market average (Table 1). They also run higher than average risks of sustaining occupational injuries resulting in permanent medical impairment (Table 2).

Occupation	Risk (injuries per 1000 employed)
Plumbers	7.1
Concreters	6.6
Carpenters	6.6
Bricklayers	4.6
Painters	3.8
Average, all occupations	**2.3**

Table 1 Occupational injury with more than 30 days disability and/or permanent impairment, sustained in 2004 (AFA 2006).

Occupation	Risk (perm. impairment per 1000 employed)
Concreters	1.9
Carpenters	2.1
Plumbers	2.1
Painters	1.0
Average, all occupations	**0.6**

Table 2 Occupational injury resulting in permanent impairment, sustained in 2004 (AFA 2006).

Preceeding events, severe injuries	Number	Prop. perm. impairment (%)
Fall, loss of balance in outdoor environment	2 096	22.3
Fall, from height	1 142	28.8
Acute strain, overload	709	11.7
Fall, loss of balance in indoor environment	1 110	19.5
Fall, in staircase, outdoor or indoor	659	20.6
All events	**18 443**	**26.6**

Table 3 Common preceeding events in severe occupational injury 2003-4 (AFA 2006).

Occupation	Proportion severe injuries due to fall from height
Painters	38.0
Bricklayers	23.3
Electricians	21.2
Carpenters	18.1
Plumber	20.8
Concreters	14.1
Average, all occupations	**6.2**

Table 4 Occupations with high proportions of severe injury due to fall from height 2003-4, n=1 142 (AFA 2006).

Occupation	Risk (number of cases per 1000 employed)
Bricklayers	1.2
Plumbers	1.2
Concreters	1.1
Carpenters	0.8
Painters	0.7
Average, all occupations	**0.3**

Table 5 Accepted occupational diseses in the building & construction industry, reported in 2002-3 (AFA 2006).

Occupation	Prop. of mens´ long-term sickness due to musculo-skeletal diseases (%)
Bricklayers	67.6
Carpenters	65.6
Plumbers	63.9
Concreters	63.1
Painters	62.4
Electricians	57.3
Average, all occupations	**51.3**

Table 6 Proportion of mens´ long-term sickness due to musculo-skeletal diseases, reported in 2003-4 (AFA 2006).

Thirty percent of all nationally reported severe occupational injuries are the result of falls or acute overexertion during movement (Table 3). Falls are particularly prone to result in permanent impairment and virtually all occupations in building and construction are exposed to extremely high risks of falling from heights (Table 4).

Building and construction occupations are also highly associated with high risks of work-related musculo-skeletal disease (Table 5 & 6).

STUDY 1:
LOSS OF BALANCE AND PERMANENT IMPAIRMENT AMONG BUILDING AND CONSTRUCTION WORKERS - AN IN-DEPTH INJURY ANALYSIS

Background

The occupational risk exposure and injury panorama among building and construction occupations indicate that injury prevention should include both technical, organisational and individual approaches, and that ergonomic analysis should be applied to optimize the interplay between the individual, the equipment and the demands of the task. One important but often under-estimated factor in the ergonomic prevention approach to falls and acute over-exertion is the individual physical capacity, and specifically, individual balance ability.

Method

In order to examine the precursors and preceeding events in relation to severe occupational injury among building and construction workers, and the potential influence of balance on the accident process and the injury outcome, a sample of cases were drawn from the register of the Swedish Labour Market Insurance (AFA) for in-depth scrutiny.

A total of 926 injury cases from construction workers, painters and electricians, resulting in permanent impairment or death, were recorded with the Insurance for the years 2000 and 2001. Out of these, 894 (97%) were assigned impairment degrees between 1-15%, 24 between 16-100% and 8 injuries were fatal.

From the permanent impairment cases, all records in the condensed free-text system coded with the verbs “lose balance”, “trip over”, “overexert”, “experience dizziness” giving rise to injuries coded “fall against/onto/through” and “overexertion” were extracted for analysis.

These injuries represented 397 (43%) of the total number of permanent impairment cases for the relevant occupational groups. From the 397 cases, some 208 records were available in the film archives of the Insurance (August 2004) and these were finally extracted for an in-depth analysis of the full individual claims files.

The individual files were scrutinized in relation to

- accident process and injurious agents reported to the Labour Inspectorate
- accident process and injurious agents reported to the Insurance
- received communications from the injured party and his/her representative
- claims settler´s notes on contacts, remittals, decisions, disablity/impairment
- investigations on negligence and liability, if relevant
- sickness certificates
- journal excerpts from treating physicians and hospitals
- investigation and assessment of permanent impairment.

In each case, the different reported versions of the accident process were assessed and injurious sub-processes, equipment, activities or environmental factors critical to the injury were identified.

None of the claims files contained a clinical assessment of individual balance ability.

In cases where the records identified balance ability as important to the accident process, and in those cases where neither equipment, activities or environmental factors were reported in the accident process, nor any other information in the claims file had identified external factors as important to the process, the injury was assessed as potentially related to balance.

Earlier falls and other information in the file indicating increased individual falls risk was recorded. Each injury case was also assessed in relation to future falls risk, eg. through impaired ability to move, pain in lower extremities or other direct or indirect potential effect on balance.

Results

Of the 208 injuries, 140 (67%) could be clearly related to equipment, activities or environmental factors. Often repeated, stereotypical processes include ladders slipping and different types of scaffolding missing parts or having been incorrectly mounted. The equipment-related accident processes represent the majority of the severe fall injuries.

The remaining sixty-eight cases (33%) were assessed as potentially related to balance. The average degree of impairment among these 68 cases was 3.7%.

Age distributions in the study						
AGE	n = 926	%	n = 208	%	n = 68	%
16 - 19	18	1,9	2	0,9	1	1,5
20 - 24	61	6,6	9	4,3	2	2,9
25 - 29	96	10,4	15	7,2	4	5,9
30 - 34	105	11,3	18	8,6	6	8,8
35 - 39	145	15,7	23	11,1	8	11,8
40 - 44	113	12,2	23	11,1	6	8,8
45 - 49	98	10,6	39	18,8	12	17,6
50 - 54	107	11,6	25	12,0	11	16,2
55 - 59	132	14,3	38	18,3	14	20,6
60 - 64	46	4,9	13	6,3	3	4,4
65 -	5	0,5	3	1,4	1	1,5

Table 7 Age distribution among building and construction workers impairment injuires 2000-01 (n=926), building and construction workers´ falls 2000-01 (n=208) and fall injuries potentially related to balance 2000-01 (n=68). AFA Aug 2004.

The age distribution in the total injury population (n=926), in the in-depth analysis group (n=208) and in the group where accidents were assessed to be potentially related to balance (n=68) is given in Table 7.

In comparing age distributions, statistical significance ($p \geq 0.95$) indicated that:

- building and construction workers over the age of 45 are over-represented in falls
- falls-related permanent impairment among building and construction workers is less common under the age of 45
- building and construction workers over the age of 50 are over-represented among permanent impairment injuries related to falls and balance
- balance-related falls are relatively less common under the age of 30

In fifty-one of the 208 falls injury files we found information of earlier falls trauma or indications of potential balance problems. In this material, the older workers (≥50) were over-represented.

Close to half of the falls injuries (102 out of 208; 49%) had led to medical consequences increasing the future risk of falling. In this group there were no significant differences in age distribution compared to the falls injury group (n=208).

Discussion and conclusions

Two out of three accident processes associated with falls leading to permanent impairment among building and construction workers in 2000-01 clearly identifies equipment, activities and environmental factors as contributing to injury. One injury out three cannot be explained by external factors and might potentially be related to balance ability.

One out of four workers in the investigated injury material had been exposed to an earlier fall or had earlier indications of increased fall risk. Of the cases presumed to be balance–related in the material (n=68), 43% had earlier indications of an increased risk of falling.

Half of the workers in the material (49%) had received such injuries that they run an increased risk of falling in the future.

Risk of falling tends to increase with age and it is significantly lower among younger building and construction workers. The balance–related risk of falling seems even more age dependent.

The primary conclusions for the prevention of falls from heights in the building and construction industry are clearly identified in the accident descriptions of the permanent impairment injuries. Two thirds of the problem should be addressed with systematic organisational and technical measures directed towards all work on ladders and on scaffolding.

Secondly, however, measures to counter-act degenerative changes in balance ability, particularly in workers above the age of 45, could represent cost-efficient injury prevention. Improved balance ability in this age group could be critical to the remaining third of the fall-risk exposure in working at height.

STUDY II:
BALANCE TRAINING –
A FUNCTIONAL PREVENTION OF FALLS AND OVEREXERTION INJURIES?

Background

The three coordinated components of the balance system – the sight (the visual stimuli), the inner ear (the vestibular system), and the nerves in the feet (proprioception) – interact to control and retain individual posture and functional balance. If the function of one of the components in the system is reduced or disabled (due to illness or environmental exposure), the other two are required to compensate for the loss.

Balance ability is affected and reduced by muscular tiredness, which leads to alternative balance strategies (Corbeil et al 2003; Adlerton et al 2004; Pendergrass et al 2003). Balance is also affected by age (Du Pasquier et al 2003) and is decreasing from the age of 25. Improved balance has been shown to prevent chronic musculo-skeletal injuries in athletes (Bandetti & Innocenti 2004) and to reduce falls among the elderly. Balance training is used in middle-aged populations (50+) to prevent falls in later years (Day et al 2002).

Balance training has not, as far as we know, been applied among professional building and construction workers, for the reduction of injury risks related to manual handling, over-exertion and falls.

Suggested project

It was suggested that a systematic balance and stability training program be tested in a larger group of active building and construction workers. The purpose of this would be to show

- how individual balance ability can be improved at different ages
- how comparably small amounts of training significantly improves balance
- how improved balance is related to reduced risks of falling
- at which cost-efficiency this form of training improves health and safety.

The long-term purpose of the project would be to design an effective balance-training concept for the Swedish building and construction trades education and continuous preventative health care in the industry. The acceptance and application of functional professional balance and stability training in the industry would lead to a reduction in falls and over-exertion injuries among building and construction workers.

Method

Funding for a trial balance training project was obtained from the Swedish construction industry's organisation for research and development (SBUF) with the agreement that cooperating companies should provide participating workers for the initial and concluding tests on paid time.

200 male subjects of all ages from four large building and construction companies were offered a stability and balance test on paid working time. Subjects were recruited by their workplace managers, but participation was voluntary. Testing was performed in a room in the building sites offices/staff rooms. Subjects were assessed singly by two researcher ergonomists (one male, one female).

The test took 20 minutes and included a questionnaire regarding perception of work accidents, risks of falling and perceived balance ability.

The subject then practiced standing on a trial wobble board, which replicated the test wobble board. Each board had a laser light on the right side edge of the board and a counterweight on the left edge. He trained for 15 seconds standing on the right leg and 15 seconds standing on his left leg. He was adviced that he could position his foot where he liked, that he could look where he liked and that if he placed the other foot on the ground to steady himself to lift it up as soon as possible.

He then carried out the test and stood for thirty seconds each, in order, on his right leg, left leg, right leg while holding a one kilogram weight in his dominant hand with the arm extended ninety degrees in front of him and finally his left leg while holding a one kilogram weight in his dominant hand with the arm extended ninety degrees in front of him. Again he was advised that he could position his foot where he liked, that he could look where he liked and that if he placed the other foot on the ground to steady himself to lift it up as soon as possible. He was also to now maintain the red laser beam upon the black line on the recording sheet on a board positioned on the floor one half meter in front of him. The recording sheet consisted of a thick middle line and 10 numbered lines equadistancely placed above and 10 below the middle line. The middle line was numbered number 1. The board was filmed during the trials to record the fluctuations.

The video recording of each 30-second trial was analysed by running the film at half speed and stopping it every second to read and record the line number. Line numbers were converted into the following scores: on the middle line = 1, lines 2 and 3 = 2, lines 4, 5 and 6 = 3, lines 7 – 11 and beyond = 4. The scores over the 30 seconds were added to give a trial score between 30 and 120.

After the conclusion of the test, the subject was given a home training program, which included a wobble board, exercises (general warmups, a variety of balance exercises, and a hamstrings stretch) and a logbook to note the date, exercises performed and exercise intensity (according to Borgs Perceived Exertion Scale).

The exercise program was designed to take approximately 15 minutes and was to be performed three times a week. The subject was asked to fax or email his logbook details to the research team on a weekly basis.

13 weeks later the subject was retested in the same manner. Prior to testing he was asked to state how frequently he had trained the balance program: 0%, 25% (average once a week), 50% (average once to twice a week), 75% (average twice a week) or 100% (average three times a week).

Results

The recruitment of participants was initiated in August 2005. Testing of subjects started in November 2005, re-testing of subjects was concluded in June 2006.

After a large number of contacts with the cooperating companies, only 133 out of the planned 200 subjects were made available for the initial test. A total of 45 out of the planned 100 subjects were available for the re-test (March through June 2006).

All tests and re-tests were conducted according to plan. However, no logbook information from participants was submitted; no faxes or emails from participants were forthcoming during the exercise period.

In the test–re-test group, 42% stated that falls were the most severe injury risk at work, 46% had been off work with an occupational injury in the past, but only 7% due to a fall. However, 60% indicated some form of discomfort associated with working at height; half the group (51%) considered their balance ability to be average, 40% said it was good or very good, while 9% said it was poor.

Table 8 summarizes the results of the tests – re-tests of the balance ability of the 45 subjects that were available to the project.

The average difference between test and re-test for the whole group (n=45) was a deterioration of balance ability by –3%. Sixteen individuals had improved their balance ability (x = +9.5%). Twenty-six individuals had deteriorated between test and re-test (x = – 10.4%).

A group of 17 among the 45, who honestly stated that they had not trained at all during the 13-week period, had not, on average, changed their balance ability at all between test and re-test.

No	YoB	Difference between test and retest				Trained? %	Change in performance between test average and re-test average:	
		Right	Left	Right +1 kg	Left +1 kg		Deteriorated (%)	Improved (%)
1	70	+ 10	+ 10	+ 4	+19	25	- 15	
2	49	+ 21	+ 13	+ 15	+ 11	25	- 20	
4	49	+ - 0	+ 6	+ 4	+ 2	0	- 3	
6	42	+ 7	+ 6	+ 6	+ 2	25	- 7	
7	52	+ 1	+ 0	+ 6	+ 7	75	- 3	
8	69	- 1	+ 3	+ 2	- 9	0		+ 1
9	56	- 12	- 12	+ 26	+ 10	0		+ 11
10	59	- 16	+ 6	+ 6	+ 23	25	- 6	
11	69	+2	+ 9	- 10	- 2	25	- 1	
12	60	- 4	+ 2	+ 5	- 8	25	- 1	
14	66	- 4	+ 8	- 1	+ 18	75		+ 7
15	53	- 10	+ 5	- 5	+ 9	75	+- 0	
16	66	+ 4	+ 13	+ 14	+ 9	75	- 15	
17	66	- 3	+ 17	- 3	+12	75	- 9	
18	59	- 2	+ 8	+ 13	+ 18	50	- 12	
19	79	- 7	+ 17	+ 8	+ 8	25	- 10	
20	86	+ 14	+ 13	+ - 0	+ - 0	25	- 9	
22	42	+ 4	+ 6	- 4	- 3	50	- 1	
23	84	- 6	+ 7	+ 3	+ 12	0	- 6	
28	72	+ 14	+ 26	+ 5	+ 9	50	- 22	
42	51	+ 19	+ 16	+ 31	+ 5	25	- 23	
43	43	+ 2	+ 21	+ 23	+ 45	25	- 31	
44	52	- 7	- 13	+ 19	+ 3	0	+- 0	
45	51	- 4	- 20	- 22	- 20	25		+ 17
48	71	+ 6	- 1	+ 3	+ 1	0	- 3	
49	47	+ 9	+ 17	- 22	- 8	25		+ 1
58	44	- 7	+ 32	+ 6	+ 11	0	- 16	
59	66	+ 1	+ 14	+ 4	+ 19	0	- 14	
60	61	- 6	+ 10	+ 15	+ 23	50	- 15	
61	74	+ 4	+ 2	+ 17	+ 11	0	- 13	
63	63	+ 12	+ - 0	- 4	- 14	0		+ 2
65	86	+ 4	- 7	- 10	+ 4	0		+ 3
66	74	- 11	+ 12	+ 21	- 9	25	- 4	
87	66	-13	-8	+5	-19	0		+ 10
88	57	+5	+14	-14	-3	0	+- 0	
90	70	+9	+4	-1	+6	0	- 6	
92	69	-15	+-0	-12	-18	25		+ 14
96	47	-1	-3	-17	-3	50		+ 6
97	71	-16	-10	-21	-24	25		+ 17
98	72	+5	+12	+-0	+5	50	- 7	
106	76	-9	-14	-5	-13	0		+ 13
108	85	-9	-25	-9	-15	25		+ 19
127	57	-5	-5	+1	-13	25		+ 9
128	77	-7	-11	-12	-15	0		+ 14
132	67	-5	-4	-4	-13	0		+ 8
N = 45						17 @ 0		

Table 8 Year of birth, individual test and re-test results, stated level of training and change in performance for the 45-group.

DISCUSSION AND CONCLUSIONS

The conclusions to be drawn from this health and safety intervention are either

- that balance and stability training has no effect on building and construction workers, or
- that the workers who agreed to participate in the test and re-test did, in fact, not conduct the training sessions as instructed.

Our conclusion is, that, in view of the documented positive effects of moderate balance and stability training (REF), this group of workers did not undertake any balance training according to the program during the project.

A more important conclusion from this study is that even this type of simple, non-demanding, physical training program, directed at a group with a proven need for the documented effects of such a program, will fail due to motivational factors.

Health and fitness exercise as applied injury prevention, supported and partly funded by the employer and conducted in a voluntary fashion, will not be an effective way to reduce the risk of severe injuries at work.

REFERENCES

Adlerton AK, Moritz U, Moe-Nilssen R, (2004) Forceplate and Accelrometer measures for evaluating the effect of muscle fatigue on postural control during one-legged stance.. *Physiother Res Int 8 (4) 187-99.*

Ansökan SBUF (2004) Balansträning - funktionell prevention av fall och belastningsskador.. *CentralGalaxen/KTH Syd.*

AFA (2003) Allvarliga arbetsskador och långtidssjukskrivning i Sverige 2003. Stockholm.

AFA (2004) Allvarliga arbetsskador och långtidssjukskrivning i Sverige 2004. Stockholm

Bandetti, Innocenti (2004) Postural control in order to prevent chronic locomotor injuries in athletes. *Ital J Anat Embryol, 108 (4): 189-94.*

Corbeil P, Blouin JS, Baoquin F, Nouqier V, Teasdale N (2003) Perturbation of the postural control system induced by muscular fatigue. *Gait Posture 18 (2) 92- 100.*

Day L, Fildes B, Gordon I, Fitzharris M, Flamer H, Lord S (2002) Randomised factorial trial of falls prevention among older people living in their own homes. *BMJ Jul 20; 325(7356): 128.*

Du Pasquier RA, Blanc Y, Sinnreich M, Landis T, Burkhard P, Vingerhoets, FJ, (2003) The effects of ageing on postural stability: a cross-sectional and longitudinal study. *Neurophysiol Clin 33 (5) 213-8.*

Pendergrass TL, Moore JH, Gerber JP (2003) Postural Control after a two mile run. *Military Medicine 168 (11) 896 - 903.*