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ERGONOMICS OF FLAT MOPS ERGONOMIC COMPARISON OF FIVE WAYS OF USING FLAT MOPS

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ERGONOMICS OF FLAT MOPS ERGONOMIC COMPARISON OF FIVE WAYS OF USING FLAT MOPS

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SUMMARY

In daily cleaning practice, flat mops are often used to clean floors. The method of application is to wipe the floor with a wrung out flat mop, whereby surface as well as slightly adhesive dust, dirt and other contamination is removed. In everyday practice, different techniques of movement are used: the *vacuum cleaning movement*, the *figure-of-eight movement* and *adjoining track movement*.
The objective of this comparative research is to determine the different physical loads of the five different ways of using a flat mop: which of these five ways requires the lowest physical exertion or load.
The five ways of using flat mops are the *adjoining track movement*, the *figure-of-eight movement* and the *vacuum cleaning movement* whereby (in regular practice) the movement is made by the arms, a vacuum cleaning movement with a rocking movement of the upper body while walking sideways and a vacuum cleaning movement with a rocking movement of the upper body while walking backwards.
Five experts in the field assess the load on the body while executing work with the flat mop while mopping methods are researched by means of an analysis of the work posture during mopping activity.
A specialist cleaner executes the mopping. The precise execution of the different mopping methods is predetermined. The work postures of the different methods of mopping are recorded with a video camera and subsequently analysed (Task Recording and Analysis by Computer (TRAC)). The measurements are executed during 10 minutes of mopping with a microfiber flat mop on a marmoleum floor.
The expert assessment of the mopping is executed based on video recordings and completed questionnaires. During the assessment the physical load, the load due to repetitive work postures, uncomfortable movements and energetically tiring activities are investigated separately.
Because the two research methods are not directed at the same mopping parameters, the results of both methods need to be considered in relationship with each other, as they are complementary to a certain degree. Research has shown that:

- adjoining track movement is coupled with the lowest physical load. This method is characterized by less uncomfortable work postures, less load due to repetitive movement and less energetic load than the other flat mopping methods.
- the *figure-of-eight movement* has the most unfavourable score with regard to uncomfortable work postures, the repetitive movement, the energetic load and the total physical load. For this reason, it can be said that the *figure-of-eight movement* is the most physically taxing movement (has the highest physical load).
- the differences in physical loads for the three variants of the *vacuum cleaning movement* are relatively small and not unequivocal; the differences are apparently not so large that they are (can be) unequivocally demonstrated with the research methods applied.

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CHAPTER 1 INTRODUCTION

1.1 Background and history

In the preliminary investigation '*Ergonomics of flat mops; Ergonomic comparison of two different mopping methods'* the physical load on the body during the vacuum cleaning movement and the *figure-of-eight* movement was investigated. The research was executed with experienced cleaning staff. The cleaning staff received instruction about the flat mop method and, after also watching a video, they executed both of the mopping methods. During the mopping action, the muscle activity, the energetic load and the work postures were measured. After completion of the activities the experimental subjects evaluated the degree of (dis) comfort of both methods.
The overall findings of the research are:

- the load on the muscles during flat mopping (both methods) is low: round about 7.5 percent of the maximum muscle load;
- the energetic load of flat mopping (both methods) is low;
- there are clear differences in the motor skills of cleaning staff;
- flat mopping with the vacuum cleaning movement requires that the back is bent more often and deeper than the *figure-of-eight* movement
- on flat mopping with the *vacuum cleaning* movement, the arm that holds the bottom of the handle is bent away from the body axis more often and with more force than it is with the *figure-of-eight* movement,
- the preference of the cleaner for a certain method is an individual choice.

The cleaning staff were not given prior intensive training to execute the methods according to an 'official' way. Therefore, it can be assumed that they executed the methods as they would execute them in daily practice, adjusted to their personal preference and fitness.
The result of the research can therefore be assumed to be largely representative for the activity as found in normal, daily practice.
In discussions about the results of the preliminary investigation in the technical committee of VSR, this resulted in posing a more encompassing question namely: how do the different methods compare in a situation where these methods are executed according to a 'standard'. During the video recordings of the flat mopping with vacuum cleaner movement, it was noted that there are three obviously different execution variants. The question was therefore expanded to include each of these variants.

1.2 Scientific and applied research flat mops

In daily cleaning practice, flat mopping is commonly used to clean floors. With flat mopping, the floor is wiped with the aid of a moist flat mop so that loose dirt as well as slightly adhering contamination is removed. (Duisterwinkel, Terpstra et al., 1996). Three movement techniques are commonly used for mopping in daily practice: the vacuum cleaning movement, the

figure-of-eight movement and the *adjoining track* movement. These movements are part of the teaching material of the Vereniging Schoonmaak Research (VSR) which are more or less standardized (VSR, 2011).

Because flat mops are frequently used for large floor surfaces, cleaning staff often works with mops for extended periods of time. Therefore, it is of great importance that movement techniques are used for mopping that tax the body as little as possible. Several researchers have investigated the physical load exerted on the body during the activity of mopping.

Hagner et al. (Hagner and Hagner, 1989) executed comparative research between mopping while using a *figure-of-eight* movement and mopping while using an *adjoining track* movement. In the *figure-of-eight* movement the cleaner walks backwards while making a figure-of-eight movement with the mop (in front of him/her). In the *adjoining track* movement in this research, the cleaner walks backwards while the mop is moved from front to back. The mop is not positioned next to the cleaner but rather kept in front of the cleaner. The physical load was established by means of measuring heart frequency (ECG), Electromyography (EMG) and with the aid of video analysis of posture and movements. The panel (11 cleaners) experienced less strength and local muscle strain during the *adjoining track* movement than during the *figure-of-eight* movement. The researchers nevertheless suspected that the static load incurred during the *adjoining track* movement could be harmful during extended periods of mopping. The measurements did not show any difference in heart frequency or in oxygen uptake. However, substantial individual differences were ascertained in work posture and movement in both methods. The average productivity measured was 17 m2/minute (dispersion 13 to 22) in the *figure-of-eight* movement and 15 m2/minute (dispersion 10.5 to 25.5) in the *adjoining track* movement.

Søgaard et al. (Søgaard, Laursen et al., 2001) compared the physical load of the *figure-of-eight* movement made with a mop with the vacuum cleaning movement made with a scrubbing brush with a cloth. They measured the force exerted on the handle by the cleaner by means of a special handle. In addition, they used EMG to register the activity of 6 muscle groups in the shoulders. Søgaard concludes despite the different movement patterns between mopping and scrubbing, only slight differences are measured between the force exerted and the muscle activity.
There are no known comparative figures about the physical load in mopping with a flat mop while using the *vacuum cleaning* method, which is prevalent in the Netherlands, the a*djoining track* method and the *figure-of-eight* method. The objective of this research is to fill this gap.

1.3 Research inquiry

The research is directed at the physical load of the different mopping methods.
The methods of mopping that are being evaluated are:

1. making a 'figure-of-eight' with a flat mop,
2. mopping by means of dragging the mop alongside the body and making adjoining tracks and
3. making the same movement with a mop as one would with a vacuum cleaner.

The research question posed is:

How does the physical load of different methods of execution compare if the *figure-of-eight* movement, the *vacuum cleaner* movement and the adjoining track movement are executed according to current understanding?

Chapter 2 RESEARCH

2.1 Overall work method

Test conditions were established before commencing with the factual research. The point of departure was daily cleaning practice. After establishing the test conditions and the measurement procedure, a research protocol was drafted.
The VSR Technical Committee was subsequently consulted about the research protocol

The physical load exerted on the body while working with the various flat mop methods was investigated with two different methods of examination. The load on posture was examined with the Task Recording and Analysis by Computer (TRAC); this provides quantitative insight into preventing unfavourable work postures during mopping. In addition, 5 experts in this field comparatively assessed the physical load.

In the first phase of the investigation, a cleaning expert in a movement laboratory executed each of the flat mop methods in a standard manner. The actions were recorded from the front and the side with a video camera.
During the video recordings it became apparent that there are three different ways in which the vacuum cleaner movement could be executed. The most common way of application in cleaning practice is using the arms for the back and forth movement of the flat mop. There are two methods of whereby the rocking movement in the mopping action is generated in the legs. The difference between the last two methods is found in the direction of walking, which is either sideways or backwards. Because each of these three methods is a rational option for the vacuum cleaner movement, it was decided to expand the research to include 5 methods for mopping. These 5 methods are:

1. *Adjoining track movement; the flat mop is held next to the body and taken along in a dragging movement*
2. *Figure-of-eight movement*
3. *Vacuum cleaner movement with the arms*
4. *Vacuum cleaning movement; rocking while walking sideways*
5. *Vacuum cleaning movement while walking backwards*

In the posture analysis, video recordings of the different methods of flap mopping are played and the postures of the participants are registered with TRAC (Task Recording and Analysis by Computer). This system consists of a hand-held computer in which the postures are tested). This is done by means of the multi-moment method in which the portable computer sounds a beep every 15 seconds so that the current posture is entered for registry. It focuses on the angle of the torso, lateral flexion and rotation of the trunk, and abduction of the arms. Finally, after processing with the computer, it is ascertained which percentage of time (relative frequency) was spent in a flexion category (0-20 degrees, 20-60 degrees, >60 degrees). The flat mop methods are compared in these relative frequencies.

For expert assessment of the flat mop methods, the experts are given a questionnaire containing open and closed questions and the video images for completion.

2.2 Means and materials

2.2.1 Textile flat mops

A mop holder with a micro fibre flat mop (40 cm wide) was used in the testing/investigation. The handle of the mop holder can be adjusted by means of a 'button'. Prior to the activity an expert cleaner adjusted the length of the handle. The target area of the top of the handle was set at a height between the armpit and the top of the shoulder. The type of mop used is the same as type C, applied in the VSR research 'Microfiber flat mops; the influence of moisture levels on functionality"(Terpstra, Engelbertink, 2009). The cleaning surface of the microfiber flat mop has a 'terry cloth structure' and consists of 50% microfiber and 50% polyamide. Based on the results of the VSR-research, the microfiber flat mop was moistened with 160% water for the investigative research.

2.2.2 Measurement area and test floor

The analysis was executed in a movement registration hall. The hall has a relatively new industrial marmoleum floor that is in good condition. Preceding the actual tests, the floor was polished twice. The floor was free of dust and dirt before every test.

2.2.3 Expert cleaner

An expert in the field of cleaning executed the cleaning actions. The details of the expert:

specialization:	cleaning; SVS teacher and examiner, cleaning advisor,
gender:	male,
age:	61 years old,
length:	1.84 meter,
body weight:	85 kg.

2.2.4 Expert assessors

Scientists and/or experts in the field of ergonomics executed the expert assessments. The following experts executed the assessments:

Expert assessor 1:	specialization: shoulder load, professor FU; faculty of Kinesiology and at the Delft University of Technology
Expert assessor 2:	specialization: biomechanics, professor FU; faculty of Kinesiology
Expert assessor 3:	researcher at the Coronel Institute for Occupational Health, AMC UvA and Arbouw
Expert assessor 4:	registered ergonomist, OHS Union (Arbo Unie)
Expert assessor 5:	researcher Coronel Institute for Occupational Health, AMC UvA

2.2.5 Flat mops

An expert cleaner mopped a surface area of 10 meters long by 5 meters wide in the same tempo, as he would usually do this. During all of the mopping methods, the right hand is held in the lower position on the mop handle.

2.3 Measurement methods

2.3.1 Observation of work postures

During the application of each of the mopping methods, the movements were recorded with a video camera. After the measurements, the postures of the 6 participants were determined by means of observing the movements on the video registration. The video was played at normal speed. During 10 minutes of every flat mop method, the following aspects of the posture were scored every 15 seconds:

- Torso angle with regard to the vertical:
  - <20 degrees
  - 20-60 degrees
  - >60 degrees
- Lateral flexion* and/or rotation of the torso of more than 10 degrees with regard to neutral.
- Upper arm angle (left and right measured separately) with regard to vertical (abduction, ante and retro flexion)
  - <20 degrees
  - 20-60 degrees
  - >60 degrees

2.3.2 Expert assessment

Besides the semi-quantitative comparison of postures with TRAC, 5 renowned ergonomists were asked to provide a qualitative assessment of the physical load: the expert assessment. The experts were asked to assess the flat mop methods using questionnaires containing open and closed questions ('*Questionnaire regarding physical load of flat mops*', appendix 1) and with the aid of video recordings of the flat mopping methods.
In the questionnaire, the physical load is subdivided into three different types; load due to work posture, load due to repetitive movement and the energetic load. A separate questionnaire is completed for each flat mop method and detailed questions are grouped for these three types. Every expert assessed the 5 flat mop methods in a different order of sequence.

Work postures

Questions 1 up to and including 10 of the '*Questionnaire on the physical load of flat mopping*' relate to the physical load owing to work postures.
Questions 1 up to and including 6 relate to whether there are specific uncomfortable work postures. The expert assessors have to indicate the degree in which they agree with a statement about the physical load. The answer scale (Likert scalel) runs from 1 to 7; 1 being ' Strongly disagree', 3 is 'Partly disagree', 5 is 'Partly agree' and 7 is 'Strongly agree'.
Question 7 asks for names of bottlenecks in work postures in the methods of flat mopping.
Questions 8 and 9 are directed at the expected short and long-term physical effects due to work postures. Question 10 inquires after a quantitative impression of the physical load due to work postures of a mopping method. The experts mark their score on a line scale that runs from 'totally not taxing' (score 0) to 'maximum load' (score 10). The quantitative score is obtained during an inventory of the results by reading the position of the marks by means of using a template.

Repetitive movements

Questions 11 up to and including 20 of the '*Questionnaire on the physical load of flat mopping*' relate to the physical load that ensues from repetitive movement in the different mopping methods. The setup of this part of the questions is the same as that for work postures. .

Energetic load

Questions 21 up to and including 25 of the '*Questionnaire on the physical load of flat mopping*' relate to the physical load that ensues from energetic load in the different mopping methods. In principle, the setup of this part of the questions is the same as that for work postures

In the last part of the questionnaire, the assignment is to rank the five flat mopping methods from the most physically taxing to least physically taxing. First, separately according to load due to work posture, repetitive movement and energetic load. Subsequently, the complete physical load is ranked.

Chapter 3 RESULTS

3.1 Work postures:

The relative frequency of the torso angle, lateral flexion and the rotation of the torso during 10 minutes of mopping are provided in table 1.
In almost all flat mopping methods researched, the torso remains almost elongated (bend < 20°) and is not bent or rotated sideways.

	Torso angle			Lateral flexion* and/ or torso rotation	
	< 20°	20°- 60°	> 60°	wel	geen
Adjoining track movement	0	0	0	0	0
Figure of eight movement	0	0	0	0	0
Vacuum cleaning arm movement	0	0	0	0	0
Vacuum cleaning rocking backward walk movement	0	0	0	0	0
Vacuum cleaning rocking backward walk movement	0	0	0	0	0

* sideways bend

Table 1 Postures; relative frequency of torso angle, lateral flexion and torso rotation during 10 minutes of mopping.

The results for the bending angles of the upper arms in relation to the body axis during 10 minutes of mopping are provided in table 2.

	Left upper arm			Right upper arm		
	< 20°	20°- 60°	> 60°	< 20°	20°- 60°	> 60°
Adjoining track movement	65	35	0	75	25	0
Figure of eight movement	98	3	0	88	13	0
Vacuum cleaning arm movement	68	30	3	65	28	8
Vacuum cleaning rocking backward walk movement	63	38	0	70	23	8
Vacuum cleaning rocking backward walk movement	78	23	0	100	0	0

Table 2 Postures, relative frequency of bending angles of the upper arms in relation to the body axis during 10 minutes of flat mopping.

In the *figure of eight movement* the left upper arm is held parallel (angle < 20°) to the torso axis during 98% of the observations. With other flat mop methods the left upper arm is bent more than 20° from the torso axis more frequently.
In the *tilting backward vacuum cleaning movement*, the right upper arm is continuously held parallel (angle < 20°) to the torso. In the other flat mop methods the right upper arm is bent away from the torso axis to a larger or lesser degree.
In the mopping methods both arms are used in less than 9% of the observations and bent more than 60° (angle < 60°) away from the body axis.

Summarized, it could be said that in all flat mop methods, the torso is not bent or rotated; the methods do not differ from each other on this point. With regard to bending of the upper arms in relation to the torso, the figure of eight movement and the vacuum cleaning movement -

with the arms, the vacuum cleaning movement - with sideways walk exert the heaviest load on the body.

3.2 Expert assessment

3.2.1 Work postures

Assessment uncomfortable work postures

Questions 1 up to and including 6 (appendix 6) relate to whether there are specific uncomfortable work postures. The answer scale runs from 1 to 7; 1 states ' Strongly disagree', 3 is 'Partly disagree', 5 is 'Partly agree' and 7 is 'Strongly agree'. The average scores of the 5 expert assessors for each of the mopping methods are provided in table 3.

The scores in table 3 provide a comparison of which parts of the body are taxed due to uncomfortable work postures in the different flat mopping methods.
In the *figure of eight movement* the experts expect a load on the torso, head or neck, forearms/elbows and the wrists/hands. In the *vacuum cleaning movement with the arms*, the central point of load is on bending or turning the neck and head. In the *vacuum cleaning movement: rocking and moving sideways*, the central point of load is on the uncomfortable work posture of the legs. The *vacuum cleaning movement: rocking while walking backwards* exerts a comparatively similar load on the considered body parts while the adjoining track movement exerts the least overall load on the body.

Work postures; bottlenecks, short-term and long-term effects

The expert assessors evaluated the flat mopping methods for bottlenecks in work postures and possible short and long term effects in the different flat mopping methods (questions 7, 8 and 9). The bottlenecks and effects mentioned by the individual expert assessors are provided in appendix II. The following paragraph indicates which bottlenecks and effects mentioned by more than one expert assessor.

Table 3: Score for the statements about specific uncomfortable work postures Likert scale 1-7 (average of the expert assessors).

	Adjoining track	Figure of eight	Vacuum cleaning 1	Vacuum cleaning 2	Vacuum cleaning 3
There is an uncomfortable work posture due to bending or turning the torso.	2,0	3,2	3,0	2,8	2,0
There is an uncomfortable work posture due to kneeling, crouching, standing in marksman position or on one leg.	1,4	1,2	1,8	2,4	2,0
There is an uncomfortable work posture due to bending or twisting of the head or neck.	2,0	3,8	3,8	3,4	3,0
There is an uncomfortable work posture due to lifting the arms to or above shoulder height	1,2	1,0	1,0	1,0	1,2
There is an uncomfortable work posture due to bending or rotating of the forearms/elbows	2,2	4,0	1,4	1,4	2,2
There is an uncomfortable work posture due to bending of the wrists or hands.	2,0	5,0	2,2	3,2	3,6

Vacuum cleaning movement 1: *vacuum cleaning movement with the arms*
Vacuum cleaning movement 2: *vacuum cleaning movement; rocking and moving sideways*
Vacuum cleaning movement 3: *vacuum cleaning movement; rocking and moving backwards*

Bottlenecks

Adjoining track movement: Three assessors state that there are no bottlenecks.
Figure of eight movement: Bottlenecks are mainly in the wrist; the wrists are bent and twisted frequently.
Vacuum cleaning movement: arms: The bottlenecks are found in the back and neck.
Vacuum cleaning movement: rocking while walking sideways: Bottlenecks are found in a twisted upper torso (back) and neck.
Vacuum cleaning movement: rocking while walking backwards Bottlenecks are found in the back and neck.

Note: extreme bending of the wrists and exerting substantial force can be seen as harmful taxing of the body. The combination of both, exerting substantial force with bent wrists is considered as being extra taxing

Short-term effects

None of the experts foresee short-term effects due to work postures related to the adjoining track movement.

- In the *figure of eight movement* the discomfort in the wrist, neck and shoulder are mentioned.
- In the *vacuum cleaning movement: arms*; various short-term effects are possible but there is no clear opinion about which body parts would be involved.
- In the *vacuum cleaning movement: rocking while walking sideways*, the effect of the central load is on the back and neck.
- In the *vacuum cleaning movement: rocking while walking backwards;* two experts are of the opinion that there will be no short term effects while two others mention that discomfort in the neck (muscle tension or fatigue) could occur as a short-term effect.

Long-term effects

- In the *adjoining track movement*; three experts do not expect long-term effects. The other two experts mention back problems; depending on the length of time spent mopping per day.
- In the *figure of eight movement* various long-term effects are considered possible; there is no unequivocal verdict about which body parts are involved.
- In the *vacuum cleaning movement with the arms* the central point of possible load is in the back and neck.
- In the *vacuum cleaning movement rocking while walking sideways*, possible effects are expected in the back, arms and neck.
- In the *vacuum cleaning movement rocking while walking backwards*, discomfort in the neck is mentioned as possible long-term effect.

General verdict on work postures

The expert assessors' general impression of the physical load in flat mopping due to work postures (question 10) is expressed on a scale of 'totally not taxing' (score 0) to the 'maximum load' (score 10).
To equalize the influence of the different assessors on the average, the scores were standardized with average scores of the expert assessor concerned. The results are provided in table 4. The expert assessors evaluate the physical load ensuing from work postures in the *adjoining track movement* lower than the other flat mopping methods. The *vacuum cleaning; rocking while walking backwards* is in second place while the figure of eight was evaluated as being the most taxing / having the highest load.

Table 4: Scores for the general impression of the physical load due to work posture in the flat mopping methods; scale 0 –10 (average of the five expert assessors).

	Adjoining track	Figure of eight movement	Vacuum cleaning movement 1	Vacuum cleaning movement 2	Vacuum cleaning movement 3
General impression of physical load due to work posture in these flat mopping methods	1,63	5,34	4,13	4,22	3,20

Vacuum cleaning movement 1: *vacuum cleaning movement with the arms*
Vacuum cleaning movement 2: *vacuum cleaning movement; rocking and moving sideways*
Vacuum cleaning movement 3: *vacuum cleaning movement; rocking and moving backwards*

Ranking order of physical load due to work posture

The expert assessors ranked the five flat mopping methods in increasing order of physical load due to work posture. The method with the lowest load is given a score of 1, the highest load scores a 5. The ranking orders of the assessors and the average score are provided in table 5.

The average ranking order corresponds with the average scores for the general impression on the 10 point scale (question 10; table 4); however, the difference between the vacuum cleaning movement with the arms and the vacuum cleaning movement rocking, walking sideways in table 4 is not included in table 5.

Table 5: Ranking order of the degree of physical load due to work posture; 1 is the lowest load.

	Assessor 1	Assessor 2	Assessor 3	Assessor 4	Assessor 5	Sum
Adjoining track	1	1	1	1	1	1
Figure of eight	4	3	5	5	5	4,4
Vacuum cleaning with arms	5	5	2	3	4	3,8
Vacuum cleaning: rocking, walking sideways	3	3	4	4	2	3,2
Vacuum cleaning: rocking, walking backwards	2	3	3	2	3	2,6

3.2.2 Repetitive movements

Assessment of uncomfortable movements

Questions 11 to 16 are aimed at specific, uncomfortable, repetitive movements. The answer scale runs from 1 to 7; 1 is described as 'Strongly disagree', 3 as 'Partly disagree', 5 as ' Partly agree' and 7 as ' Strongly agree'. The average scores of the 5 expert assessors of every flat mopping method are provided in table 6.

Repetitive movements; bottlenecks, short-term and long-term effects

The expert assessors named the bottlenecks in the repetitive movements and possible short and long- term effects of the different mopping methods (questions 17, 18 and 19). The bottlenecks and effects as specified by the individual expert assessors are provided in appendix III. The following paragraph indicates which bottlenecks or effects were signalled by more than one expert assessor.

	Adjoining track	Figure of eight	Vacuum cleaning 1	Vacuum cleaning 2	Vacuum cleaning 3
There is an uncomfortable work posture due to bending or turning the torso.	1,4	3,2	2,8	2,6	1,4
There is an uncomfortable work posture due to kneeling, crouching, standing in marksman position or on one leg.	1,4	1,2	2,2	3,0	2,8
There is an uncomfortable work posture due to bending or twisting of the head or neck.	1,6	2,8	3,2	2,2	1,8
There is an uncomfortable work posture due to lifting the arms to or above shoulder height.	1,0	1,0	1,0	1,0	1,2
There is an uncomfortable work posture due to bending or rotating of the forearms/elbows.	1,2	5,0	1,8	1,6	2,4
There is an uncomfortable work posture due to bending of the wrists or hands.	2,2	6,0	2,6	3,0	3,6

Vacuum cleaning movement 1: *vacuum cleaning movement with the arms*
Vacuum cleaning movement 2: *vacuum cleaning movement; rocking and moving sideways*
Vacuum cleaning movement 3: *vacuum cleaning movement; rocking and moving backwards*

Table 6: Score for the statements about specific, repetitive movements; Likert scale 1-7 (average of the five assessors).

Bottlenecks

- Three experts did not note any bottlenecks in the *adjoining track* movement.
- The bottleneck in the *figure of eight movement* is found in the wrist (unanimous); the wrists are bent and/or twisted very frequently.
- In the *vacuum cleaning movement with the arms*, the bottlenecks are found in the wrist and the ('upper') arm.
- The bottleneck in the *vacuum cleaning movement: rocking, walking sideways* is the load on the legs and the hand/wrist.
- In the *vacuum cleaning movement: rocking, walking backwards*, the bottleneck is found in the legs due to the rocking movement and in the hand/wrist.

Short-term effects

- None of the experts expect short-term effects due to repetitive movement in the *adjoining track movement*.
- In the *figure of eight* movement, discomfort in the wrist/lower arm and fatigue in the arms are mentioned.
- In the *vacuum cleaning movement with the arms*, fatigue mentioned as a short-term effect.
- In the *vacuum cleaning movement: rocking, walking sideway*s various short term effects are considered to be possible but there is no unequivocal judgement about which parts of the body could be involved.
- In the *vacuum cleaning movement: rocking, walking backwards*, fatigue in the legs and discomfort in the 'lower' arm are mentioned.

Long-term effects

- Three experts do not expect long-term effects from the *adjoining track movement*. Two experts mention complaints/discomfort of the wrist.
- In the *figure of eight* movement, discomfort in the upper limbs is considered possible; elbows and wrist.
- In the *vacuum cleaning movement with the arms*, the central point of possible effects is in the shoulders and arms (elbow).

- In the *vacuum cleaning movement: rocking while walking sideways* possible effects is expected in the shoulders and arms (elbow).
- In the *vacuum cleaning movement: rocking while walking backwards*, two experts are of the opinion that there are no expected long-term effects while others mention arm discomfort/ complaints as possible short-term effect.

General verdict on repetitive movements

The general impression of the physical load due to repetitive movements in the flat mopping methods (question 20) is expressed in scores on a scale that runs from 'totally not taxing' (score 0) to 'maximum load' (score 10) is given in table 7)
To equalize the influence of the different assessors on the average, the scores were standardized with the average scores of the expert assessor concerned.

The expert assessors evaluate the physical load ensuing from repetitive movement. The *adjoining track movement* clearly scores better than the other flat mopping methods. The *vacuum cleaning movement with the arms: rocking while walking sideways* and the *vacuum cleaning movement; rocking while walking backwards* are evaluated as being more or less equal. The figure of eight was evaluated as being the most taxing / having the highest load.

Table 7: Score for the general impression of the physical load due to repetitive movement in the flat mopping methods: scale 0-10 (average of the five expert assessors.

	Adjoining track	Figure of eight movement	Vacuum cleaning movement 1	Vacuum cleaning movement 2	Vacuum cleaning movement 3
General impression of the physical load due to work postures for flat mopping methods	1,64	5,95	3,36	3,58	3,11

Vacuum cleaning movement 1: *vacuum cleaning movement with the arms*
Vacuum cleaning movement 2: *vacuum cleaning movement; rocking and moving sideways*
Vacuum cleaning movement 3: *vacuum cleaning movement; rocking and moving backwards*

Ranking order of physical load due to repetitive movement

The expert assessors ranked the five flat mopping methods in increasing order of physical load due to work posture. The method with the lowest load is given a score of 1, the highest load scores a 5. The ranking orders of the assessors and the average score are provided in table 8.

Table 8: Ranking order for flat mopping methods with regard to the physical load due to repetitive movement. .

	Assessor 1	Assessor 2	Assessor 3	Assessor 4	Assessor 5	Sum
Adjoining track	1	1	1	1	1	1
Figure of eight	5	5	5	5	5	5
Vacuum cleaning with arms	4	3	2	4	4	3,4
Vacuum cleaning: rocking, walking sideways	2	3	4	3	2	2,8
Vacuum cleaning: rocking, walking backwards	3	3	3	2	3	2,8

The average ranking order corresponds with the average scores for the general impression on the 10 point scale (question 20; table 7; however, the difference between the vacuum cleaning movement with the arms and the vacuum cleaning movement rocking, walking sideways in table 7 is not included in table 8.

3.2.3 Energetic load

Assessment of straining activities

Question 21 is related to the physical load due to straining activities in the different flat mopping methods. The answer scale runs from 1 to 7; 1 is described as 'Strongly disagree', 3 as 'Partly disagree', 5 as ' Partly agree' and 7 as ' Strongly agree'. The average scores of the 5 expert assessors of every flat mopping method are provided in table 9.

	Adjoining track	Figure of eight	Vacuum cleaning 1	Vacuum cleaning 2	Vacuum cleaning 3
There is a combination of straining activities (walking, cycling, pushing, pulling, lifting, etcetera) that this leads to a clear feeling of general fatigue in all of the body.	2,8	3,6	3,2	3,8	3,8

Vacuum cleaning movement 1: *vacuum cleaning movement with the arms*
Vacuum cleaning movement 2: *vacuum cleaning movement; rocking and moving sideways*
Vacuum cleaning movement 3: *vacuum cleaning movement; rocking and moving backwards*

Table 9: Score for the statements about the general degree of fatigue ensuing from flat mopping methods; Likert scale 1-7 (average of the five expert assessors).

The scores in table 9 shows a comparative degree of a combination of taxing activities that lead to general fatigue in the whole body. The verdict of the expert assessors is that the *adjoining track movement* is the least taxing. The vacuum cleaning movement with the arms will result in a slightly stronger feeling of general fatigue. This effect is the most comparable in the other flat mopping methods and the *figure of eight movement*.

Energetic load; bottlenecks, short and long-term effects

The expert assessors have indicated which bottlenecks are possible in the short and long term given the energetic load of the different flat mopping methods (questions 22, 23 and 24). The individual expert's assessment of bottlenecks and effects are found in appendix IV. The following paragraph indicates which bottlenecks and effects signalled by more than one expert assessor.

Bottlenecks

- Three experts state that there are no bottlenecks in the *adjoining track movement*.
- Three experts state that there are no bottlenecks in the *figure of eight movement*.
- Three experts state that there are no bottlenecks in the *vacuum cleaning movement with the arms*.
- Two experts state that there are no bottlenecks in the *vacuum cleaning movement: rocking, walking sideways*. The other experts consider it a bottleneck to continually place the weight from the one leg on the other in the vacuum cleaning movement: rocking, walking backwards.

Short-term effects

- None of the experts expect short-term effects due to energetic load in the *adjoining track movement*. The other two experts mention fatigue as a short-term effect of this method.
- Three experts foresee no short-term effects due to the energetic effects of the *figure of eight* movement.
- Three experts do not expect short-term effects due to the energetic load of the *vacuum cleaning movement with the arms*. The other two experts mention fatigue as a short-term effect of this method.

- Two experts do not expect short-term effects due to the energetic load of *vacuum cleaning movement: rocking, walking sideways*. The other three experts mention fatigue as a short-term effect of this method.
- Two experts do not expect short-term effects due to the energetic load of *vacuum cleaning movement: rocking, walking backwards*. The other three experts mention fatigue as a short-term effect of this method.

Long-term effects

None of the experts expect long-term effects to ensue from the energetic load of the flat mopping methods.

General verdict on energetic load

The general impression of the energetic load in the flat mopping methods (question 24) is expressed in scores on a scale that runs from 'totally not taxing' (score 0) to 'maximum load' (score 10) is given in table 10)

To equalize the influence of the different assessors on the average, the scores were standardized with average scores of the expert assessor concerned.

The expert assessors evaluate the energetic load ensuing from the *adjoining track movement* better than the other flat mopping methods. A clear difference in the evaluation has not been distinguished between the other flat mopping methods.

Table 10: Score for the general impression of energetic load in flat mopping methods: scale 0-10 (average of the five expert assessors)

	Adjoining track	Figure of eight movement	Vacuum cleaning movement 1	Vacuum cleaning movement 2	Vacuum cleaning movement 3
General impression of the physical load due to work postures for flat mopping methods	2,56	3,38	3,13	3,63	3,54

Vacuum cleaning movement 1: *vacuum cleaning movement with the arms*
Vacuum cleaning movement 2: *vacuum cleaning movement; rocking and moving sideways*
Vacuum cleaning movement 3: *vacuum cleaning movement; rocking and moving backwards*

Ranking order of physical load due to energetic load

The expert assessors ranked the five flat mopping methods in increasing order of energetic load due to work posture. The method with the lowest load is given a score of 1, the highest load scores a 5. The ranking orders of the assessors and the average score are provided in table 11.

The physical load in the *adjoining track movement* has the lowest score. The *figure of eight* and the *vacuum cleaning movement with arms* scored higher. An even higher load is expected from the *vacuum cleaning movement: rocking, walking sideways* and the *vacuum cleaning movement: rocking, walking backwards*. The average ranking order globally corresponds with the average scores for the general impression on the 10-point scale (question 25; table 10).

Table 11: Ranking order for flat mopping methods with regard to the degree of energetic load: 1 is the least taxing

	Assessor 1	Assessor 2	Assessor 3	Assessor 4	Assessor 5	Sum
Adjoining track	4	1	3	1	4	2,6
Figure of eight	1	2,5	3	5	2	2,7
Vacuum cleaning with arms	2	2,5	3	2	5	2,9
Vacuum cleaning: rocking, walking sideways	3	4,5	3	4	2	3,3
Vacuum cleaning: rocking, walking backwards	5	4,5	3	3	2	3,5

3.2.4 Total assessment on physical load

The expert assessors ranked the five flat mopping methods in increasing order of physical load due to work posture. The method with the lowest load is given a score of 1, the highest load scores a 5. The ranking orders of the assessors and the average score are provided in table 12.

The physical load in the *adjoining track movement* has the lowest score. The highest score is expected from *figure of eight movement*. There were substantial differences in the expert's assessment regarding the three flat mopping methods involving variations on the *vacuum cleaning movement*; on average *vacuum cleaning movement with arms* has the better score in evaluation.

	Assessor 1	Assessor 2	Assessor 3	Assessor 4	Assessor 5	Sum
Adjoining track	2	1	1	1	1	1,2
Figure of eight	3	2	5	5	5	4
Vacuum cleaning with arms	1	5	2	3	4	3
Vacuum cleaning: rocking, walking sideways	4	3,5	4	4	2	3,5
Vacuum cleaning: rocking, walking backwards	5	3,5	3	2	3	3,3

Table 12: Ranking order with regard to the total physical load; 1 is the least taxing.

CHAPTER 4
SUMMARY AND CONCLUSIONS

In daily cleaning practice, flat mopping is commonly used to clean floors. With flat mopping, the floor is wiped with the aid of a moist flat mop so that loose dirt as well as slightly adhering contamination is removed. In daily practice, three movement techniques are commonly used for mopping: the *vacuum cleaning movement, the figure-of-eight movement and the adjoining track movement*.

In this research, the physical load of the five methods of flat mopping is compared to each other: Which of these methods has the lowest physical load on the body. The five methods for using flat mops are the *adjoining track movement*, the *figure-of-eight movement* and the *vacuum cleaning movement* whereby (in regular practice) the movement is made by the arms, a vacuum cleaning movement with a rocking movement of the upper body while walking sideways and a vacuum cleaning movement with a rocking movement of the upper body while walking backwards.

Experts in the field researched the load on the body while working with the flat mopping methods. The experts made an analysis of work postures during the execution of the different flat mopping methods.
A specialist cleaner executed the mopping. The precise execution of the different mopping methods is predetermined. The work postures of the different methods of mopping were recorded with a video camera and subsequently analysed (Task Recording and Analysis by Computer (TRAC)). The measurements were executed during 10 minutes of mopping with a microfiber flat mop on a marmoleum/linoleum floor.
The expert assessment of the mopping was executed based on video recordings and questionnaires. During the assessment the physical load, the load due to repetitive work postures, uncomfortable movements and energetically tiring activities are investigated separately.
Because the two research methods are not directed at the same mopping parameters, the results of both methods need to be considered in relationship with each other, as they are complementary to a certain degree. The research results per type of physical load are summarized below.

4.1 Work postures

TRAC analysis

The TRAC analysis shows almost all methods of flat mopping means that the back is held in a stretched position and is not turned: in this point they do not differ from each other.

In the *figure of eight movement* and in the *vacuum cleaning movement walking backwards* the left upper arm is in a position of being bent at less than 20° in relation to the torso axis most of the time (78 to 100%). Bending the arms more at more than 60° away from the body axis does not happen when using these two methods. It does however, occur to a small degree when using the *vacuum cleaning movement with the arms* and the *vacuum cleaning movement; rocking while walking sideways*.

On the whole, the *figure of eight movement* and the *vacuum cleaning movement*; rocking while walking backwards score better on this point, making them less taxing in comparison to the other methods.

Expert assessment

In assessing the presence of specific uncomfortable work postures it became apparent that in each of the five flat mopping methods, there are uncomfortable work postures to a larger or lesser degree. The body parts that are taxed differ for the various flat mopping methods. In the *figure of eight movement* the load is on the arms/hands/wrists. With the exception of the *adjoining track movement*, all other methods show a load on the neck and head.
According to the expert assessors, the *adjoining track movement* shows less bottlenecks and possible short-term effects than any other of the methods. In the *figure of eight* the emphasis is on the arms and wrists and on the back and neck. In the three vacuum cleaning movements the emphasis is on the back and neck.

The expert assessors' general impression of the physical load due to work postures is that the load will be slighter for the *adjoining track movement* than for the other four methods of flat mopping. The figure of eight movement has the least favourable assessment.
In the ranking of the flat mopping methods by the expert assessors shows a comparable picture: the least taxing is the *adjoining track movement*, the *vacuum cleaning movement*; rocking *while walking backwards* is more taxing followed by the *vacuum cleaning movement with the arms* and the *vacuum cleaning movement walking sideways*. The last place (the highest load) is for the *figure of eight* movement.

Summarized, it could be said that the *adjoining track movement* yields the least physical load due to work postures and the largest physical load occurs with the *figure of eight* movement. The physical loads of the vacuum cleaning movements do not differ from each other substantially.
The *adjoining track movement* could possibly exert some load on the back. The figure of eight movement taxes the arms and wrists the most while the vacuum cleaning methods exert a load on the back and neck.

4.2 Repetitive movements

In the assessment of the presence of specific uncomfortable specific movements, it showed that all the flat mopping methods have these movements to a greater or lesser degree. The body parts that are taxed differ per flat mopping method. In the assessment of the repeti-

tive movements, the figure of eight shows the load to be mainly on the arms, hands and wrists. Taken on the whole, the physical load due to repetitive movement is the lowest in the *adjoining track* movement.

On the whole, the expert assessors deem the chances of bottlenecks and both short-term and long-term effects due to repetitive movements ensuing from the *adjoining track movement* to be the smallest.
Possible bottlenecks and both short-term and long-term effects for the *figure of eight movement* can clearly be found in the wrist and lower arm and also in the back and neck.

The expert assessor's general impression of the physical load due to repetitive movements in the flat mopping methods is that the load will be slighter for the *adjoining track movement* than in the other four methods of flat mopping. The *figure of eight movement* has the least favourable assessment.

In the ranking of the flat mopping methods by the expert assessors shows a picture that is comparable to the general impression: the least taxing is the *adjoining track movement*, the *vacuum cleaning movement; rocking while walking backwards* is more taxing followed by the *vacuum cleaning movement with the arms* and the vacuum cleaning movement walking sideways. The *figure of eight movement* has the highest load.

Summarized, it could be said that the *adjoining track movement* yields the least physical load due to repetitive movements and the largest physical load occurs with the *figure of eight movement*. The physical loads of the vacuum cleaning movements do not differ from each other substantially. The *vacuum cleaning movement; rocking while walking backwards* method scored marginally better than the other two methods. No clear bottlenecks or short and long term effects are expected in the a*djoining track movement*.
The figure of eight movement taxes the arms and wrists the most with uncomfortable movements while the *vacuum cleaning movements* exert a load on the back and neck. Furthermore, the walking movement in the *vacuum cleaning movement rocking while walking sideways* and the *vacuum cleaning movement; rocking while walking backwards* are considered to be uncomfortable.

4.3 Energetic load

In the evaluation of the degree of general fatigue in the body because of the flat mopping methods, the scores for the different flat mopping methods is comparable. However, the total degree of fatigue is considered to be lower with the *adjoining track movement* than it is with the other methods.

On the whole, the expert assessors consider the chances of bottlenecks and both short and long term effects due to energetic load ensuing from the different methods to be limited. The experts mention fatigue as possible short-term effect. Possible bottlenecks and short-term effects in the *vacuum cleaning movement; rocking while walking backwards* and the *vacuum cleaning movement; rocking while walking sideways* are found in the sideways and backwards stepping movement and the load on the legs, according to the experts.

The general impression of the expert assessors with regard to ranking the physical and energetic load, the load is slightly less in the *adjoining track movement* than in the other four

methods of flat mopping. In the ranking of the flat mopping methods, the *figure of eight movement* and the *vacuum cleaning with the arms* score more or less the same while the *vacuum cleaning movement; rocking while walking sideways* and the *vacuum cleaning movement; rocking while walking backwards* score slightly worse.

In summary it can be said that the lowest load ensues from the *adjoining track movement*, the *figure of eight movement* and the vacuum cleaning movement with the arms. The energetic load of the *vacuum cleaning movement; rocking while walking sideways* and the *vacuum cleaning movement; rocking while walking backwards* is possibly a little larger.

4.4 Summerizing and conclusions

- *Adjoining track movement* yields a lower load due to uncomfortable work postures, repetitive movement and energetic load. The total verdict of the experts is that the total physical load is lower than it is in the other flat mopping movements. Because the TRAC measurement of the work postures also did not show clear differences, it can be said that the *adjoining track movement* has the lowest physical load.
- The *figure of eight* movement has the most unfavourable score with regard to uncomfortable work postures, repetitive movements, energetic load and total physical load. Therefore, it can be said that the *highest physical load accompanies the figure of eight movement.*
- The differences in physical load of the three different *vacuum cleaning methods* are relatively small and not clear-cut: the differences are apparently not large enough to be established with the research method applied.

CHAPTER 5
LITERATURE

Duisterwinkel, A., P. M. J. Terpstra, *et al*. *Basisprincipes vuilverwijdering en stofbestrijding.* Tilburg: Samson. 1996. 156 p.

Hagner, I. M., M. Hagner. Evaluation of two floor-mopping work methods by measuring of load. Ergonomics, v.32, n.4, p.401-408. 1989.

Søgaard, K., B. Laursen, *et al*. *Dynamic loads on the upper extremities during two different floor cleaning methods.* Clinical biomechanics, v.16, n.2001, p.866-879. 2001.

Terpstra, M. J., A. M. B. Engelbertink. *Microvezelvlakmoppen; Invloed van het vochtgehalte op de functionaliteit*. Vereniging Schoonmaak Research. Wageningen: oktober 2009, p.53. 2009. (080901)

VSR Teaching material on cleaning methods, Module 6 Microfibre flat mop. Association for Cleaning Research (VSR – Vereniging Schoonmaak Research) 2011

APPENDIX 1: QUESTIONNAIRE ON PHYSICAL LOAD IN FLAT MOPPING

This questionnaire relates to the physical load that you detect when you see facility staff cleaning the floor with a moist mop. You will see video recordings of five different methods for mopping. You first watch the frontal and sagittal video recordings of the cleaning activities after which you will complete the corresponding questionnaire.
The video recording of each of the flat mopping methods takes about 4 minutes (2 minutes frontal and 2 minutes sagittal).

1. Adjoining track movements: walking forwards while the flat mop is moved forward alongside the body while exerting light pressure.
2. Figure of eight: walking backwards whereby the flat mop is moved in the shape of an 8 along the floor surface.
3. Vacuum cleaning movement in regular practice: walking sideways whereby the flat mop is moved along the floor surface with a similar movement as if vacuum cleaning, generating the movement from the arms.
4. Vacuum cleaning movement according to the methodology from the SVS institute: the flat mop is moved along the floor just like a vacuum cleaner. The vacuum cleaning movement comes from the legs and the walking direction is sideways.
5. Vacuum cleaning movement according to the methodology of the SVS institute, but the walking direction is backwards

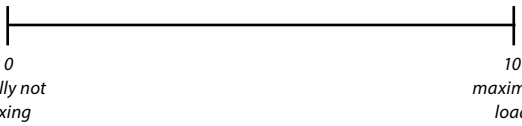
Watch the video recording of the five different methods in the following sequence:
1. *Adjoining track*
2. *Figure of eight*
3. *Vacuum cleaning movement in regular practice*
4. *Vacuum cleaning movement according to the methodology of the SVS-institute*
5. *Vacuum cleaning movement according to the methodology of the SVS-institute but the walking direction is backwards.*

Immediately after watching the video recordings of the first flat mopping method, you complete the corresponding questions. You then watch the video recording of the next flat mopping method and complete the corresponding question list.

Once you have completed the question lists for the separate flat mopping methods, you complete the last question list related to ranking the flat mop methods.
We expect that the assessment will require more than two hours of your time.

We are very grateful for your contribution to his research!

Method xxx								
Circle the applicable (1-7):		**Totally disagree**		**Partly disagree**		**Partly agree**		**Totally agree**
	Work postures							
1	There is an uncomfortable work posture due to bending or turning the torso.	1	2	3	4	5	6	7
2	There is an uncomfortable work posture due to kneeling, crouching, standing in marksman position or on one leg.	1	2	3	4	5	6	7
3	There is an uncomfortable work posture due to bending or twisting of the head or neck.	1	2	3	4	5	6	7
4	There is an uncomfortable work posture due to lifting the arms to or above shoulder height.	1	2	3	4	5	6	7
5	There is an uncomfortable work posture due to bending or rotating of the forearms/elbows.	1	2	3	4	5	6	7
6	There is an uncomfortable work posture due to bending of the wrists 1 or hands	2	3	4	5	6	7	
7	What are the bottlenecks in the work postures of this flat mopping method?							
8	Which short-term physical effects are possibly caused by the work postures of this flat mopping method?							
9	Which *long-term* physical effects are possibly caused by the work postures of this flat mopping method?							
10	General impression of the physical load due to work postures of this flat mopping method (mark the line at the appropriate place)	*0 totally not taxing*						*10 maximum load*

Method xxx								
Circle the applicable (1-7):		**Totally disagree**		**Partly disagree**		**Partly agree**		**Totally agree**
	Repetitive movements							
11	There is an uncomfortable work posture due to bending or turning the torso	1	2	3	4	5	6	7
12	There is an uncomfortable work posture due to kneeling, crouching, standing in marksman position or on one leg.	1	2	3	4	5	6	7
13	There is an uncomfortable work posture due to bending or twisting of the head or neck.	1	2	3	4	5	6	7
14	There is an uncomfortable work posture due to lifting the arms to or above shoulder height.	1	2	3	4	5	6	7
15	There is an uncomfortable work posture due to bending or rotating of the forearms/elbows.	1	2	3	4	5	6	7
16	There is an uncomfortable work posture due to bending of the wrists or hands.	1	2	3	4	5	6	7
17	What are the bottlenecks in the repetitive movements of this flat mopping method?							
18	Which short-term physical effects do he repetitive movements of this flat mopping method possibly cause?							
19	Which *long-term* physical effects do the repetitive movements of this flat mopping method possibly cause?							
20	General impression of the physical load due to repetitive movements of this flat mopping method (mark the line at the appropriate place).							

Methode xxx								
Circle the applicable (1-7):		**Totally disagree**		**Partly disagree**		**Partly agree**		**Totally agree**
	Energetic load							
21	There is a combination of straining activities (walking, cycling, pushing, pulling, lifting, etcetera) that this leads to a clear feeling of general fatigue in all of the body.	1	2	3	4	5	6	7
22	What are the bottlenecks in the energetic load movements of this flat mopping method?							
23	Which *short-term* physical effects does the energetic load of this flat mopping method possibly cause?							
24	Which *long-term* physical effects does the energetic load of this flat mopping method possibly cause?							
25	General impression of the physical load due to the energetic load of this flat mopping method (mark the line at the appropriate place).	*0 totally not taxing*						*10 maximum load*

Ranking the flat mopping methods

Rank the five flat mopping methods (adjoining track, figure of eight, vacuum cleaning methods) in order of the degree of physical load due to ***work postures***. Start with the flat mopping method with the highest physical load on number 1.

1. .....

2. .....

3. .....

4. .....

5. .....

Rank the five flat mopping methods (adjoining track, figure of eight, vacuum cleaning methods) in order of the degree of physical load due to ***repetitive movements***. Start with the flat mopping method with the highest physical load on number 1.:

1. .....

2. .....

3. .....

4. .....

5. .....

Rank the five flat mopping methods (adjoining track, figure of eight, vacuum cleaning methods) in order of the degree of energetic load due to ***energetic load***. Start with the flat mopping method with the highest physical load on number 1.

1. .....

2. .....

3. .....

4. .....

5. .....

Final assessment: rank the five flat mopping methods (adjoining track, figure of eight, vacuum cleaning methods) in order of the degree of total physical load. Start with the flat mopping method with the highest physical load on number 1.

1. .....

2. .....

3. .....

4. .....

5. .....

APPENDIX 2: BOTTLENECKS IN WORK POSTURES

The expert assessors have listed the bottlenecks that accompany the different flat mopping methods (question 7). In the following list, the bottlenecks are shown separately, as they were listed per expert. The sequence is the same per expert.

Adjoining track movement:
- none
- none
- none
- slightly turned position of the torso
- handle length not adjusted to position / power in hands

Figure of eight movement:
- extension position left wrist
- prolonged neck flexion
- dorsal extension of the lower hand (in particular): high frequency of substantial dorsal extension
- the slightly twisted torso posture
- high frequency of turning the mop

Vacuum cleaning movement with the arms:
- possible depression of the left shoulder, pinching off the PB
- bent + twisted neck
- bottleneck could be exorotation and load on the back leg/foot
- the slightly twisted and bent posture of the head and torso
- handle not adjusted to the position / power hand / wrist

Vacuum cleaning movement from the legs; walking sideways:
- rotated position in relation to direction of work
- torso rotation neck flexion
- 1) exorotation and load on back knee, foot or leg; 2) dorsal extension top wrist / hand
- the slightly twisted and bent posture of the head and torso
- handle not adjusted to the position / power hand / wrist

Vacuum cleaning movement from the legs; walking backwards:
- ankle plantar flexion left, probably more in repetitive movements
- torso rotation neck flexion

- in particular dorsal extension of the top hand: high frequency with substantial dorsal extension
- a hunched over posture of the head and a slightly hunched over posture of the torso
- handle not adjusted to the position / power hand / wrist

Short-term work postures n

The experts mentioned the following short-term effects due to work postures (question 8):

Adjoining track movement:

- n/a
- n/a
- none
- none
- none

Figure of eight movement:

- wrist complaints
- discomfort / neck fatigue
- discomfort in wrist /lower arm
- high tension in the neck and shoulder muscles
- discomfort in wrist / hand/ shoulder

Vacuum cleaning movement with the arms:

- fatigue left shoulder
- discomfort
- complaints ankle / foot / leg
- back and neck complaints
- none

Vacuum cleaning movement from the legs;

- fatigue in lower back
- discomfort + back fatigue + neck
- complaints 1) ankle / knee / leg (? Probability of meniscus complaints) 2) wrist / hand
- increased muscle tension (complaints) in the neck, shoulder and back regions
- none

Vacuum cleaning movement from the legs; walking backwards:

- n/a
- fatigue / discomfort back + neck
- discomfort in wrist / lower arm
- increased muscle tension in the neck / shoulder muscles
- none

Long-term effect of work postures
The experts mentioned the following long-term effects due to work postures (question 9):

Adjoining track movement:
- n/a
- n/a
- none
- back complaints
- depends on time duration per day; -local discomfort top hand/ wrist; - one-sided torso rotation
- therefore local back discomfort

Figure of eight movement:
- arthrosis?
- neck complaints
- possible wrist and elbow ailments
- over load
- depending on the time duration per day: - (a)specific ailments upper extremities

Vacuum cleaning movement from the arms:
- supraclic nerve, n.thoracicis longus
- neck complaints
- ailments to ankle / foot/ leg
- over load of the back and neck muscles. Possible lumbago or hernia
- depending on the time duration per day: - discomfort in neck, upper back, right arm, left arm, shoulder

Vacuum cleaning movement from the legs: walking sideways:
- back complaints
- neck complaints
- ailments 1) ankle / knee / leg 2) wrist / hand
- over load complaints, back complaints
- depending on the time duration per day: - discomfort of the neck, back and right arm

Vacuum cleaning movement from the legs: walking backwards:
- not applicable
- neck complaints
- wrist and lower arm afflictions
- over strained neck and shoulder muscles
- depending on the time duration per day: - discomfort of the neck, back and right arm

APPENDIX 3: BOTTLENECKS IN REPETITIVE MOVEMENTS

The expert assessors have indicated where the bottlenecks are found with regard to repetitive movement in the flat mopping methods (question 17). In the following list, the bottlenecks are specified per expert; the order of sequence is the same all the time

Adjoining track movement:
- the rotation of the mop by changing from side to side
- n/a
- none
- there are no repetitive movements
- handle has not been adjusted to position / power hands

Figure of eight movement:
- extension/wrist flexion, especially left
- repetitive extension of the wrist of the bottom hand and to a lesser degree, the top hand wrist.
- dorsal extension of the lower hand in particular: high frequency with substantial dorsal extension
- the steering movement of the left arm and hand. Extension of the wrist (and flexion) high frequency of turning the mop

Vacuum cleaning movement from the arms:
- left shoulder
- repeated flexion of the wrist and top arm
- bottleneck could be the exorotation and load on the back leg/foot
- repetitive abduction, especially in the left arm
- handle has not been adjusted to position / power of the hands /wrists

Vacuum cleaning movement from the legs; walking sideways
- back
- n/a
- 1) exorotation and load on the back knee, foot or leg; 2) dorsal extension top wrist / hand
- the back and forth movement of the legs and arms
- handle has not been adjusted to position / power hands /wrists

Vacuum cleaning movement from the legs; walking backwards:
- stepping out movement, ankle left = calves
- n/a

- particularly the dorsal extension of the top hand: high frequency with substantial dorsal extension
- the rocking movement from front to back on the legs
- handle has not been adjusted to position / power of the hands / wrists

Short-term effects of repetitive movements
The following short-term effects were mentioned by the expert assessors (question 18):

Adjoining track movement:
- n/a
- n/a
- none
- none
- none

Figure of eight movement:
- pain
- discomfort, fatigue in lower arm
- discomfort in wrist / lower arm
- fatigue. Ailments in lower arm muscles and in the neck muscles
- discomfort wrist / hand / shoulder

Vacuum cleaning movement from the arms:
- fatigue
- discomfort lower arm
- complaints ankle / foot / leg
- fatigue
- none

Vacuum cleaning movement from the legs; walking sideways:
- back complaints
- n/a
- complaints 1) ankle / knee / leg (? Probable meniscus complaints) 2) wrist / hand
- fatigue
- none

Vacuum cleaning movement from the legs; walking backwards:
- fatigue in calves
- n/a
- discomfort in wrist /lower arm
- tired legs, ankle, knee and hip complaints
- depending on the time of day, discomfort neck, back, right arm

Long-term effects of repetitive movements
The following long-term effects were mentioned by the expert assessors (question 19):

Adjoining track movement:
- wrist complaints
- n/a
- none
- none
- depending on time duration per day, local discomfort top hand / wrist; - one-sided torso rotation therefore local back discomfort

Figure of eight movement:
- arthrosis?
- wrist / elbow complaints
- possible wrist and elbow complaints
- over load complaints of neck shoulder and arm muscles
- depending on the time duration per day: - (a)specific ailments upper extremities

Vacuum cleaning movement from the arms:
- Damage to the plexus brachialis (a network of nerves in the neck and shoulder area)?
- wrist / elbow complaints
- over taxing the shoulder (bursitis) and elbow (tennis arm)
- depending on time duration per day, local discomfort neck, upper back, right arm, left arm, shoulder

Vacuum cleaning movement from the legs; walking sideways:
- back complaints
- n/a
- complaints 1) ankle / knee / leg 2) wrist / hand
- over load complaints
- depending on time duration per day, local discomfort neck, back, right arm

Vacuum cleaning movement from the legs; walking backwards:
- n/a
- n/a
- wrist / lower arm afflictions
- over taxing of the ankle, knee and hip joints
- depending on time duration per day, local discomfort neck, back, right arm

APPENDIX IV: BOTTLENECKS IN ENERGETIC LOAD

The following list provides an overview of the bottlenecks on the work postures for the different work methods (question 22) as separately specified by the experts.

Adjoining track movement:
- walking distance
- extensive duration will result in fatigue
- none
- pulling the mop alongside the body
- none

Figure of eight movement:
- arm- torso movement
- prolonged (backward) walking
- none
- making figure of eight movements requires substantial energy and coordination
- none

Vacuum cleaning movement from the arms:
- n/a
- prolonged walking forward and backward
- none
- moving the arms back and forth continuously
- none

Vacuum cleaning movement from the legs: walking sideways:
- stepping in and out + torso rotation
- stepping backwards and forwards
- none
- moving the weight from one leg to the other and pulling the mop from front to
- back.
- none

Vacuum cleaning movement from the legs: walking sideways backwards:
stepping out + ankle plantar flexion
stepping backwards and forwards
none
the repetitive movements
none

Short-term effects of energetic load

The experts have specified the following short-term effects due to energetic load (question 23):

Adjoining track movement:
- general fatigue
- tired legs
- none
- none
- none

Figure of eight movement:
- n/a
- tired legs
- none
- fatigue
- none

Vacuum cleaning movement from the arms:
- n/a
- tired legs
- none
- fatigue
- none

Vacuum cleaning movement from the legs; walking sideways:
- fatigue in the legs, around the hip and knee joints (the hip in particular) abductor?
- tired legs
- none
- fatigue
- none

Vacuum cleaning movement from the legs; walking backwards:
- tired calves
- fatigue in legs
- none
- fatigue
- none

Long-term effects of energetic load

The experts have specified the following long-term effects due to energetic load (question 24):

Adjoining track movement:
- n/a
- none
- none
- none
- none

Figure of eight movement:
- n/a
- n/a
- none
- none
- none

Vacuum cleaning movement from the arms:

n/a
n/a
none
none
none

Vacuum cleaning movement from the legs: walking backwards:
- n/a
- n/a
- none
- none
- none

Vacuum cleaning movement from the legs: walking backwards:
- muscle ache
- n/a
- none
- none
- none

VSR (the Association for Cleaning Research) is the independent platform for the professional cleaning industry. As the knowledge Institute for all market parties in the field of cleaning maintenance, VSR strives to objectively add focus and professionalize the cleaning profession by means of research, information and training.

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