

# Ergonomic assessment of a cordless backpack vacuum cleaner designed by Nilfisk Advance.

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2 January, 2009

## Bakground

Nilfisk Advance in Sweden requested an ergonomic assessment of a cordless backpack vacuum cleaner prototype. The design of this backpack vacuum cleaner (BPVC) is very much the same as the preciously evaluated prototype with the exception of the added battery placed at the bottom of the machine. The aim of the assessment was to establish if the added weight of the battery would cause any extra perceived strain or discomfort. The battery has resulted in an added weight of approximately 1,4kg. The entire BPVC thus weighs 7,2kg as opposed to 5,8kg in the previous model.

Studies show that carrying weights on the back exceeding 6kg may restrict lung function, cause extensive skin irritation and put the thoracic nerve at risk of injury (Holewijn, 1990; Magee, 1997; Legg and Cruz, 2004, Lai and Jones, 2001). The restrictions on lung function corresponds to the magnitude of the load, i.e. the heavier the more is the vital capacity and expiratory volume reduced (Muza et al., 1989). In terms of the position of the load on the back scientific evidence demonstrate that placing the heavier parts of a load higher up when carrying it on the back is both energy efficient and perceived as less strenuous (Struempfle et al. 2004; Obusek et al., 1997) which corresponds to the general principle in popular press that recommend packing the lighter weights in a backpack at the bottom and the heavier at the top (Howe and Getchell, 1995).

## Method

The methods of evaluation in the assessment was comprised of a post field trial questionnaire requiring the participants to indicate both their rate of perceived exertion (RPE), physical discomfort and subjective ratings of specific design criteria after 6 minutes of vacuum cleaning a non-carpeted and carped area. The task had to be pursued during 6 minutes in order

to reach a steady state. All areas to be cleaned were soiled with un-boiled rice. Subjects were instructed to adapt a cleaning rate equivalent to what they usually have and would be able to maintain during a regular working day. The same went for the stroke pattern. The majority, however, used the back-and-forth movements as opposed to the side-to-side movements. Each subject was aided in adjusting the BPVC in order to achieve a comfortable and correct fit. After the trial of each vacuum cleaner subjects were required to fill in a questionnaire stating their levels of RPE during the vacuuming task as well as their subjective evaluation of the vacuum cleaners overall usability. For more information regarding the questionnaire set-up and layout see the report "Ergonomic assessment of a backpack vacuum cleaner designed by Nilfisk Advance, using a comparative study design".

Five healthy subjects (two females and three males) between the ages of 21 and 54 years old were recruited to participate in the study. A selection of individuals of different stature was consciously chosen in order to meet the vast differences found in the end-user group. They had no history as professional cleaners and their experience in cleaning was limited to that of regular household duties. Apart from this, the following criteria had to be met in order to qualify: no history of significant musculoskeletal disorders or other health problems and fluent in Swedish. All subjects took part on their own free will and signed a form of consent regarding the use of the data collected from the study. Their mean and median height, weight and age are listed in Figure 1.

Characteristics of the subjects	mean	median
Age (yrs)	41,6	44
Stature (cm)	171,6	174
Weight (kg)	75,6	74

Figure 1.

The had the following features:

- A broad, well-padded and adjustable hip-belt.
- Wide, well-padded and adjustable shoulder straps of the larger size, used in the previous study.
- Moveable and adjustable chest strap within a range of either 25 cm (on the regular harness).
- A flexible and adjustable plastic frame designed to permit a greater freedom of movement of the upper extremities, some degree of shock-resistance and for further individual adjustments according to back lengths.
- Plastic quick-release buckles on all straps.
- The attachment of the pipe to the machine slotted into a track with a 360 degree range of motion.
- The pipe itself had the traditional plastic construction.
- The exhaust was placed at the lower end of the machine and blows up and away from the body.
- The battery was placed at the bottom of the machine, below the hip belt.
- The weight of the machine was 7,2 kg and the position of the load on the back was classified as "low" and close to the body.

## Results

The rates of perceived exertion (RPE) was generally higher when using the cordless model as opposed to the regular BPVC. Previously the subjects rated the exertion as "slightly strenuous" which equals 11,5 on the RPE-scale. With the current cordless model the rate of exertion was classified as "somewhat strenuous" which equals 13 on the RPE-scale, see figure 2.

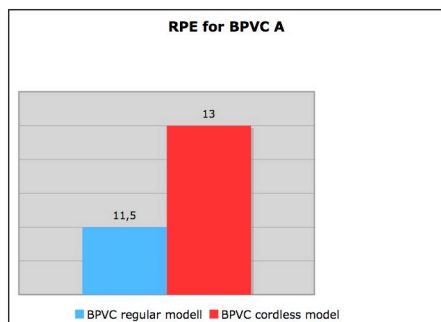


Figure 2.

Furthermore, the results from the questionnaire regarding design aspects indicate that the subjects perceived the weight of the machine as less satisfactory. The weight score was 38 as opposed to 58 on a 100-point scale, i.e. the higher the score the better, see figure 3.

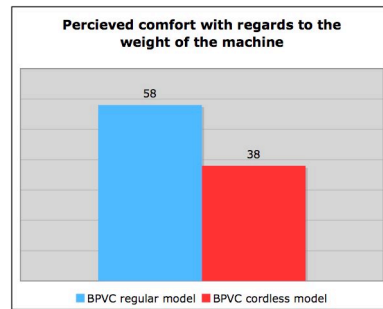


Figure 3.

The open –ended questions also indicated that the weight of the BPVC was perceived as a negative feature of the BPVC if the aim is to use the machine for a whole working day. However, the response to the cordless feature was positively commented on as it simplified vacuum cleaning in tight areas and in places where electricity connection may be difficult. The overall judgement was that the cordless feature increased freedom and that the cordless BPVC was a very good option when the period of vacuum cleaning was short, i.e no more than an hour.

Questions regarding other features such as the comfort and adjustability of the shoulder harness, the end result of the cleaned area and the overall usability of the BPVC resulted in the same ratings as the previous study made on the regular modell. The larger harness when used by smaller subjects gave lower ratings of adjustability and comfort, just as found before. Two different sizes should thus be available when purchasing the BPVC.

Rating of discomfort gave no significant findings.

## Discussion

The results indicate that the increased weight of the cordless BPVC is perceived as more strenuous than the lighter regular BPVC. The increased perceived exertion may be due solely to the increased weight and/or due to the position of the weight at the bottom of the machine. It may be worth while to position the heavier load at the top of the machine as heavier loads placed higher up on the back is both more energy efficient and perceived as less strenuous (Struempfle et al. 2004; Obusek et al., 1997)

## Conclusion

The cordless BPVC was perceived as heavier and the act of vacuum cleaning was also

perceived as more strenuous. However, the response to the cordless feature was positively commented on as it simplified vacuum cleaning in tight areas and in places where electricity connection may be difficult. The overall judgement was that the cordless feature

increased freedom and that the cordless BPVC was a very good option when the period of vacuum cleaning was short, i.e no more than an hour.

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