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Effectiveness of interventions to reduce workload in refuse collectors
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Chapter 1

General introduction
1.1 Introduction

Refuse collectors around the world are at risk for musculoskeletal complaints. Studies from the East\textsuperscript{177} to the West\textsuperscript{2,34}, and from the North\textsuperscript{66,108} to the South\textsuperscript{106,115} reported a high risk for musculoskeletal complaints among refuse collectors. The Netherlands forms no exception to this finding. Verbeeck\textsuperscript{167} found that the incidence rate of disability for work among refuse collectors in the capital of The Netherlands was about four times higher than the rate among office workers of the same refuse collecting company. The high physical workload in refuse collecting is seen as an important risk factor for musculoskeletal and physical fatigue complaints\textsuperscript{69,87,108,121}. Moreover, in The Netherlands the amount of domestic refuse is still increasing. From the year 1993 to 2000 the amount per citizen increased from 478 to about 566 kg (http://statline.cbs.nl).

Refuse collecting can be classified as a job with a low socio-economic status. Therefore, the high incidence of musculoskeletal complaints also contributes to socio-economic health inequalities\textsuperscript{138}. The last two decades, there has been a growing awareness of the relation between socio-economic status and health\textsuperscript{175}. In The Netherlands, citizens with a low socio-economic status live 12 years less in good health than persons with a high socio-economic status. Besides differences in lifestyle and living conditions, unfavourable working conditions seem to play an important role\textsuperscript{138}. Schrijvers et al.\textsuperscript{127} concluded from a study among 6932 Dutch working men and women that a substantial part (varying between 35% and more than 80%) of the association between occupational class and a less than good perceived general health could be attributed to a differential distribution of hazardous physical working conditions and low job control across occupational classes. This suggests that interventions aimed at improving these working conditions might contribute to a reduction in socio-economic inequalities in health in the working population. Especially, interventions at the workplace aiming at a reduced risk of musculoskeletal complaints might be effective because of the relatively low cost involved\textsuperscript{158}. In conclusion, prevention of musculoskeletal and physical fatigue complaints among refuse collectors is of importance. A reduction of the physical work demands and physical workload might be an effective tool resulting in fewer complaints in this job with a low socio-economic status.

In The Netherlands, the increase in work demands and the high prevalence of health complaints, have led to the introduction of a unique job specific guideline for refuse collectors. This Dutch refuse collecting guideline is based on the results of a national study performed in the period between 1990-1993\textsuperscript{28,42,43,137}. The age-dependent guideline specifies for three refuse collecting methods (polythene bags, two-wheeled containers and four-wheel containers) the maximum amount of refuse that may be collected during an 8-hour working day, or the maximum number of bags, two-wheeled containers or four-wheeled containers that may be collected during an 8-hour working day, or the maximum number of hours that
the task collecting may be performed during an 8-hour working day. The guideline has taken effect in 1998 and is enforced by the Labour Inspection Service of the Dutch Ministry of Social Affairs and Employment. Before implementing additional interventions, several refuse collecting organisations wanted to know the effect of these interventions on work demands, physical workload and prevalence of musculoskeletal and fatigue complaints. Therefore, a simple cause-effect model is formulated that describes the relationship between these terms. The model is based on the models by Kilborn \(^{70}\), Van Dijk et al. \(^{159}\), Westgaard and Winkel \(^{172}\) and Sluiter \(^{130}\) (figure 1).

![Figure 1. A simple cause-effect model between a production system, work demands, physical workload, and musculoskeletal and fatigue complaints. The effect modifying role of physical capacity and ability to recover as well as the main points of application of ergonomic interventions are given.](image)

In The Netherlands, most production systems to collect domestic refuse make use of either a refuse truck and polythene refuse bags or a refuse truck with an automatic lifting device and two-wheeled refuse containers. The polythene bags and two-wheeled containers are collected by a team of a truck driver and one or more refuse collectors. The work demands are often formulated in terms of tasks performed. These work demands determine in a large part the actual working method of the team and the resulting postures, movements and exerted forces. In this way, the work demands result in a physical workload, depending on the physical capacity of each team member. The physical workload can be divided in a mechanical workload (for instance, compression force on the low back) and an energetic workload (for
instance, heart rate). Depending on the physical capacity and the ability to recover, the loading of these systems can eventually lead to musculoskeletal and fatigue complaints. To prevent negative health outcomes, ergonomic interventions are mainly aimed at improving the production system and the work demands. For instance, the introduction of the two-wheeled container instead of polythene bags can be classified as an intervention aimed at improving the production system by reducing the mechanical workload and the Dutch refuse collecting guideline is an intervention aimed at improving the work demands by reducing the energetic workload. Due to the latency in the development of complaints, the dependent variables in ergonomic intervention studies mainly represent the work demands or physical workload. Only seldom health complaints are taken as dependent variables.

Besides a distinction as to dependent variables, a distinction can be made based in the type of intervention study performed (figure 2). Two types of studies can be distinguished: studies on efficacy and studies on effectiveness. Efficacy can be defined as the extent to which a specific intervention produces a beneficial result under ideal conditions. In ergonomic research this is mostly assessed on basis of theoretical considerations or experimental studies. As already mentioned, most efficacy studies use work demands or workload instead of complaints as dependent variables to evaluate an intervention.

Of course, the ultimate aim of an ergonomic intervention is not a reduction in work demands or workload per se, but an increase in health or a reduction in the onset or worsening of complaints. The effectiveness is the extent to which a specific intervention does what it is intended to do for a defined population in a real life setting. The intervention studies in this thesis ultimately aim at reducing musculoskeletal and fatigue complaints among refuse collectors in the working situation.

![Diagram](image)

**Figure 2.** Illustration of some important terms in ergonomic intervention research (a: non-work-related fraction, b: work-related fraction, c: efficacy, d: effectiveness, e: sustainability), based on Westgaard & Winkel. The size of the arrows depend on the type of intervention and dependent variable.
1.2 Objective of this thesis
The main objective of this thesis was to determine the efficacy of four ergonomic interventions in terms of work demands and workload of refuse collectors in The Netherlands. The ergonomic interventions were selected by stakeholders to ensure organisational commitment. The four ergonomic interventions were:
I. Increase in the number of two-wheeled containers at a gathering point,
II. Redesign of a two-wheeled container with a content of 0.240 m$^3$,
III. Job rotation between collecting bags, sweeping streets and driving a sweeping machine, and
IV. Job rotation between collecting two-wheeled containers and driving a refuse truck.
The first two interventions are aimed at improving the production system. The first intervention is most likely to affect the energetic workload in terms of its duration and the second intervention the mechanical workload in terms of its level. The last two interventions are aimed at improving the work demands and probably have an effect on both energetic and mechanical workload in terms of duration. For the fourth ergonomic intervention, the efficacy was not only assessed in terms of workload but also in terms of recovery. Moreover, in a separate study the effectiveness was determined in terms of need for recovery and (sick leave due to) musculoskeletal complaints.

1.3 Outline of the contents
In chapter 2 the work demands and the physical workload of refuse collectors in three different time periods are described to find out whether earlier interventions have been as effective as expected. Chapter 3 evaluates the effect of the number of two-wheeled containers at a gathering point on the energetic workload and on the perceived exertion in a mock up situation. Chapter 4 is aimed at the effect of a redesign of a two-wheeled container. Firstly, § 4.1 evaluates the effect of the design factors centre of mass and handle location on exerted forces and mechanical loading of the low back and shoulder in a laboratory setting. Subsequently, in § 4.2 the mechanical and perceived workload are compared between working with a redesigned two-wheeled container and working with a standard two-wheeled container in a mock up situation. Chapter 5 describes the effect of job rotation on the work demands and workload in two types of refuse collecting. In § 5.1 the effect of job rotation between collecting polythene bags, sweeping streets and driving a sweeping machine is evaluated on work demands and physical workload. In § 5.2 the effect of job rotation between collecting two-wheeled containers and driving a refuse truck is evaluated on work demands, workload and recovery. Finally, in chapter 6, the results of a prospective study on the effects of job rotation between collecting two-wheeled containers and driving a refuse truck on need
for recovery and (sick leave due to) musculoskeletal complaints are described. *Chapter 7* presents the epilogue, and leads to recommendations for practice and research.