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Manual handling in refuse collection

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Summary

Objectives

1. To review scientific literature on manual handling operations in refuse collection.
2. To identify risk factors for musculoskeletal disorders in refuse collection in an urban environment. A variety of collection systems for domestic and trade waste were studied including the collection of recyclable waste in wheeled bins and non-recyclable waste in bags and wheeled bins.
3. To provide recommendations for methods of reducing the risks of musculoskeletal disorders in refuse collection.

Main Findings

1. A significant body of, largely European, scientific literature exists on manual handling in refuse collection.
2. The findings of the literature are consistent with the observations made in this study.
3. Refuse collection and recycling practices vary between and within localities.
4. A wide range of factors, such as terrain, architecture, road layouts and traffic, the habits of drug addicts, local feeling on wheelie bins, and time of day, can affect the kind of manual handling operations carried out in refuse collection.
5. Refuse collectors use a variety of methods to make their task easier, such as sending crew members ahead of the vehicle to gather refuse bags into piles.
6. Coding of postures using OWAS showed that overall, stressful postures were adopted for small percentages of time with almost all falling into Action Category 1, which is deemed to not require action to reduce the risks from them.
7. Manual handling of refuse sacks usually involves handling several sacks at once, held and carried separately in each hand. Refuse collectors generally use stooping postures to pick up bags. Stooping and twisting postures occur frequently but the overall duration of each one is very short.
8. Typical weights of domestic refuse sacks are between 4 and 6 kg. Fewer than 10% weigh more than 12 kg. It is rare that a sack weighs more than 20 kg.

9. Refuse sacks are usually thrown onto the back of the vehicle rather than being lifted and placed into it. This is a dynamic action usually carried out while the worker is still walking.
10. Throwing bags into a refuse lorry requires the lifting of the hands above the shoulders, though this occurs for relatively short durations.
11. The heights at which bags have to be thrown into refuse lorries (the 'rave heights') are such that approximately half of the male working population would have problems throwing the heaviest bags into the lorries.
12. Bag handling occurs at a moderately high frequency with approximately 7 lifts, carries and throws per minute during periods of actual collection of bags.
13. Refuse in bags can be hazardous due to the presence of sharp objects such as broken glass or discarded syringes. There are also hazards from foul or infectious material.
14. On some occasions the old style of round non-wheeled dustbin are still manually lifted and emptied into the refuse vehicle.
15. A variety of sizes of wheelie bin are used by business premises and large residential buildings, ranging from the domestic 240 litre size to 1100 litre Eurobins and Paladin bins. Some business premises bag their refuse in preference to a wheelie bin service.
16. There is a general move from Paladins to Eurobins since they are easier to handle manually and do not require specialised clamping systems for mechanical handling. Some local authorities have installed bulk refuse storage systems that are emptied mechanically without any manual handling.
17. Pushing and pulling virtually never occur on rounds dealing with refuse in bags. Considerable amounts of pushing and pulling occur on rounds dealing with wheelie bins. Pulling of bins is slightly more common than pushing them.
18. Even on rounds that are ostensibly dealing solely with wheeled bins, significant manual handling of refuse bags and other loose refuse also occurs.
19. Refuse collectors walk considerable distances each day. Apart from when travelling in the refuse lorry, their lower limb postures are largely standing or walking.
20. The cardiovascular demands of the different methods of refuse collection do not appear to be excessive for normally fit workers.

Main Recommendations

1. Wherever possible, refuse collection should be carried out using wheelie bins of appropriate sizes rather than bags or small dustbins.
2. As Government policy is to increase the amount of waste recycled, partly through the taxation of landfill, schemes which encourage householders to separate recyclable waste will become more common. Where recycling collections are made by local authorities or their contractors, separate wheelie bins should be provided wherever possible.
3. The schedules of recycling / no-recycling collections should be matched to the relative volumes of recyclable and non-recyclable material to keep the volumes collected approximately constant.
4. Where use of wheelie bins is impractical, collection of bags is likely to continue unless bulk collection facilities can be implemented. In these circumstances recycling should be encouraged by the provision of green bins and bags.
5. Old-style dustbins should never be emptied manually into refuse vehicles. Where householders still use them they should be encouraged to line them with black bags before putting refuse into them.
6. Eurobins should be:
 - a. Handled by two people whenever possible;
 - b. Transported across dropped kerbs wherever possible and particularly when being returned after emptying which is when most of the pulling back up kerbs would usually occur.
7. When moving any size of bin the refuse collectors should:
 - a. Ensure there is sufficient space to manoeuvre the bin by moving surrounding obstacles, opening doors, etc.
 - b. Try to avoid pushing or pulling the bin across obstacles such as steps and kerbs.
 - c. Seek assistance when having trouble moving a bin - particularly if moving it up or down a slope or kerb or step.
8. Manufacturers should be encouraged to consider the following changes / aspects of the bins:
 - a. Increasing wheel diameter;

- b. Use of lightweight materials - especially in the larger 360 and 1100 litre Eurobins.
9. Where possible, lorries without lifting gear and with a low rave height should be provided for rounds dealing solely with bags. Where the same vehicles are used for different rounds, consideration should be given to demounting the lifting gear for the bags-only rounds.
 10. Where lifting gear is fitted, the rave bar should be lowered when not collecting wheelie bins. This recommendation should only be ignored if specific safety risks that outweigh the manual handling risks of keeping the bar up can be clearly demonstrated.
 11. The refuse collectors should be involved in a scheme with the relevant local authorities to identify areas where improvements could be made to their work environment. This would consider where kerbs should be dropped, ramps installed, alleys and pavements resurfaced and rubble or building waste cleared.
 12. Refuse collectors and local residents / trade proprietors should all be involved in schemes to reduce the refuse collectors' workload. The refuse collectors could identify the premises and types of problems they face, e.g., fetching bins from the backs of shops, etc. Suggestions could then be made to residents / proprietors about how they can help.
 13. Refuse collectors should be provided with effective PPE for their hands and legs. This would not only help reduce the risk of lacerations, infections and disease but it may also enable refuse collectors to grip, hold and carry refuse in optimal ways, i.e., held in a balanced way and not held so far away from the legs.

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1. INTRODUCTION

This work was undertaken as a result of a request from Field Operations Directorate (FOD) in the HSE Bristol Area Office. FOD asked the Ergonomics Section at HSL for help with a project they were carrying out on behalf of the Services Sector looking at risks of refuse collection. While there is a wide range of workplace hazards that refuse collectors are exposed to, this report examines the risks of musculoskeletal disorders (MSDs) as a result of the manual handling elements of the work.

Staff from the Human Factors Unit of HSE's Health Directorate (HD D2) in Bootle were also involved in the work. FOD had identified an urban local authority in the south east of England that was willing to participate in the project. A visit was made on 6 and 7 December 2000 in order to gather information relating to the manual handling work done by the refuse collectors.

2. LITERATURE REVIEW

2.1. Occupational health problems in refuse collection

Poulsen *et al.* (1995) reviewed the range of occupational health problems that occur in refuse collection and their possible causes from a number of studies largely published in Europe and not in English.

They characterised the work of refuse collectors as involving much heavy lifting as well as pulling and pushing of containers and carts. Both of these are known risk factors for low back pain. They described the work as also possibly containing work above shoulder level, frequent forceful exertions, static contractions and extreme joint positions. These are occupational risk factors for MSDs in the neck, shoulders and arms.

They listed a wide variety of factors that influence the work conditions of refuse collectors (Table 1). They reported Danish incidence rates of a variety of health problems between 1984 and 1992 and calculated relative risks for refuse collectors when compared to the total work force (Table 2). The relative risk for refuse collectors developing musculoskeletal problems was 1.9, i.e., refuse collectors were 1.9 times more likely to develop musculoskeletal problems than the rest of the Danish working population. They also reported accident rates for the same period (Table 3) and noted that the most commonly reported accidents were fractures, sprains, wounds, soft tissue accidents and poisonings.

Table 1. Factors influencing the work conditions of waste collectors (Poulsen *et al.*, 1995)

Type of company	Large / small / self-employed carriers		
Work organisation	Permanent / temporary employment Piece rate / hourly wage		
Type of equipment	<i>Domestic facilities</i>	Bag with / without cart Bin with / without cart Domestic containers (110, 240 litres) Large area containers (400, 600, 1100 litres)	
	<i>Waste collection truck</i>	Open lorry Closed truck	With / without comprimator Manual / automatic emptying Low / high emptying
		High / low cabin	
Type of district	Old / new multi-storey houses Old / new one-family homes Public institutions Rural residents Leisure time districts Others		
Type of waste	<i>Unseparated</i> <i>Source separated</i>	Biodegradable waste Paper Plastics Glass Residual waste Garden waste Other	
Frequency of collection	Once per day/week/fortnight/month		
Seasonal variations	Temperature/Humidity		

Table 2. Annual incidence rates, per 1000 employees, of reported health problems in Denmark, 1984 to 1992 (after Poulsen *et al.*, 1995)

Diagnostic group	Incidence rate for total work force	Incidence rate for refuse collectors	Relative risk	95% confidence interval
Reported diseases	5.5	8.3	1.5	1.4 - 1.7
Allergic respiratory diseases	0.22	0.58	2.6	1.8 - 3.9
Other respiratory diseases	0.38	0.53	1.4	0.9 - 3.9
With defective hearing	0.95	0.51	0.5	0.09 - 0.8
Musculoskeletal diseases	1.9	3.5	1.9	1.6 - 2.2
Skin diseases	0.84	1.3	1.6	1.2 - 2.0
Infectious diseases	0.06	0.36	6.0	3.6 - 10.0
Nerves / senses	0.05	0.1	2.0	0.8 - 5.3
Brain damage	0.39	0.31	0.8	0.5 - 1.4
Circulation	0.08	0.05	0.6	0.2 - 2.5
Gastrointestinal	0.05	0.14	2.8	1.3 - 6.3

Table 3. Annual incidence rates, per 1000 employees, of occupational accidents in Denmark, 1984 to 1992 (after Poulsen *et al.*, 1995)

Accident type	Incidence rate for total work force	Incidence rate for refuse collectors	Relative risk	95% confidence interval
Accidents, in general	16.8	94.6	5.6	5.4 - 5.9
Fatal accidents	0.03	0.0	0.0	
Amputations	0.2	0.22	1.1	0.4 - 2.9
Fractures	1.6	4.9	3.1	2.5 - 3.8
Sprains	5.7	45.9	8.1	7.5 - 8.6
Wounds	4.9	18.7	3.8	3.4 - 4.2
Thermal accidents	0.67	1.3	1.9	1.3 - 2.9
Soft tissue accidents	1.9	14.4	7.6	6.7 - 8.6
Chemical burns	0.15	0.87	5.8	3.5 - 9.5
Poisonings	0.12	1.7	14.2	9.9 - 20.2
Unknown types	1.5	6.6	4.4	3.7 - 5.3

They summarised studies which have estimated mechanical load during refuse collection (Table 4) and noted that several had demonstrated that the load on the L5/S1 intervertebral disc frequently exceeded recommended limits when handling all sizes of wheelie bins over curbs or pulling them.

They also summarised studies that had examined the metabolic demands of refuse collection (Table 5). Of these studies they cite Hansson and Klussell (1977) to the effect that these demands were dependent on the weight of the bags or containers. They also cited Friberg and Isaksson (1974) as finding particularly high metabolic loads when wheelie bins and bags were transported up and down stairs as compared to level ground. Stassen *et al.* (1992) found that waste collection both in bags and the smaller, domestic, wheelie bins can result in unacceptably high metabolic loads. Markslag *et al.* (1993) showed that the metabolic demands were greater during carrying and throwing 7 kg bags of rubbish than during pushing and pulling wheelie bins.

Table 4. Mechanical loads estimated in studies of refuse collection (after Poulsen *et al.*, 1995)

System	Methods	N	Mechanical load	Reference
110 and 240 litre wheelie bins	EMG, BM	6 ^a	L5/S1 torque often 200-400 Nm	Jäger <i>et al.</i> (1984)
240 and 1100 litre wheelie bins	DM, BM	1 ^a	L5/S1 torque often >170 Nm; Shoulder torque often >50-70% MVC for >10% of working day	Pedersen <i>et al.</i> (1992)
Bags	MLF, DM	116 ^b	Mean over day 14.2% MVC	Stassen <i>et al.</i> (1992)
120 and 240 litre wheelie bins	MPF, DM		Mean over day 3.8% MVC	
1100 litre wheelie bins	MPF, DM		Mean over day 22.4% MVC	
7 kg bags	DM, BM, VR	17 ^a	Standing 3400-5200N (L5/S1); walking 3240-4680 N (L5/S1)	Markslag <i>et al.</i> (1993)
120, 240 litre wheelie bins (+22, 60 kg)			Tilt/push 1510-2280 N (L5/S1); Tilt/push 1860-2650 N (L5/S1)	
1100 litre wheelie bins (+185 kg)			Lift over kerb 5400 N (L5/S1)	

Notes: N = Number of workers in study; EMG = Electromyography; BM = Biomechanical models; DM = Dynamometric measurement; VR = Video recording; MLF = Maximum lifting force; MPF = Maximum pushing force; MVC = Maximum voluntary contraction.

Table 5. Energetic load related to waste collection (Poulsen *et al.*, 1995)

System	Methods	N	Energetic level	Reference
Bags	HR, VO ₂ ,	8 ^a	58, 63% of VO _{2max} (34/54 kg)	Hansson and Klussell (1977)
Bins on cart	V _E		60, 70% of VO _{2max} (37/82 kg)	
110, 240 litre wheelie bins	HR, VO ₂	17	50% VO _{2max}	Klimmer <i>et al.</i> (1982)
1000 litre wheelie bins		(28) ^b	36% VO _{2max}	
Bags	HR	10+15 ^b	Mean work pulse 37 bpm	Boldt <i>et al.</i> (1990)
120, 240 litre wheelie bins			Mean work pulse 37 bpm (48 bpm when in basements)	
700, 1100 litre wheelie bins			Mean work pulse 39 bpm (45 bpm when empty wheelie bins returned)	
Bags	HR, VO ₂	23 ^b	HR 100 bpm; average 8 hr VO ₂ < 30% of VO _{2max}	Kemper <i>et al.</i> (1990)
Bins			HR 97 bpm; average 8 hr VO ₂ < 30% of VO _{2max}	
Bags	HR, VO ₂	116 ^b	59% of workers VO ₂ >30% VO _{2max} (8hr); 55% of workers VO ₂ >50% VO _{2max} (1hr)	Stassen <i>et al.</i> (1992)
120, 240 litre wheelie bins			51% of workers VO ₂ >30% VO _{2max} (8hr); 32% of workers VO ₂ >50% VO _{2max} (1hr)	
1100 litre wheelie bins			33% of workers VO ₂ >30% VO _{2max} (8hr); 17% of workers VO ₂ >50% VO _{2max} (1hr)	
1100 litre wheelie bins	HR	6	Work pulse 40 bpm	Luttmann <i>et al.</i> (1992)
7 kg bags	VO ₂	17 ^a	VO ₂ : waste bags > wheelie bins	Markslag <i>et al.</i> (1993)
120, 240 litre wheelie bins (+22 kg)				
1100 litre wheelie bins (+110 kg)				

N = number of subjects; VO₂ = rate of oxygen consumption; VO_{2max} = maximal rate of oxygen consumption; V_E = pulmonary ventilation rate; HR = heart rate; Work pulse = increase in heart rate above resting rate; a = Laboratory study; b = Field study

They concluded that these studies showed that refuse collectors exceeded the limits proposed by NIOSH (Waters *et al.*, 1994) for biomechanical (3400 kN on the L5/S1 intervertebral disc) and metabolic load (33% VO_{2max} for all day lifting tasks) when carrying out certain tasks. They noted that no field studies had been carried out into how factors such as work organisation, equipment, or locality affected whether the limits were exceeded or not. They suggested a survey of the industry was needed which would identify high risk work conditions and establish the relationship between them and the incidence of musculoskeletal problems. However, they noted that such a study would be extremely time and resource consuming and that since the biomechanical and metabolic loads depended on a range of work factors there could be difficulties in characterising the exposure of individual workers.

2.2. Energetic demands of refuse collection

2.2.1. Comparison of dustbins and black bags

Kemper *et al.* (1990) found that replacing the old style of round dustbins (weighing 6 kg) with black bags and a twice weekly collection with a once weekly collection had the results shown in Table 6 for ten of 35 workers in a Dutch town.

Table 6. Effect of changing from dustbins to black bags

	Daily amount	Mean weight per throw	Load as % of isometric strength	Lifts per minute	HR (bpm)	% VO_{2max}
Dustbins	6900 kg	12.8 kg	13.8%	2.7	97.4	28.3
Black bags	11700 kg	13.4 kg	14.6%	3.4	99.7	30.3
Significance	P<0.01	P<0.05	P<0.05		ns	ns

They commented that “the action of just throwing the bag into the car consisted of a far more efficient movement than the emptying of the dustbin into the car”.

2.2.2. Daily workload of refuse collectors

Kemper *et al.* (1990) studied the effect of the new working system on 23 of the refuse collectors (Table 7).

Table 7. Table 5 from Kemper *et al.* (1990) for refuse collectors handling polythene bags (n=23)

	Weight per throw (kg)	% F_{Max} per throw	Heart rate (bpm)	Heart rate at 30% VO_{2max} (bpm)	Time >50% VO_{2max} (min)
Mean	15.1	16.8	99.5	98.3	85
SD	1.43	2.5	10.2	8.2	59
Range	12.4-17.8	12.3-21.3	80.5-119.5	84.3-112.	0-200
Significance	ns		ns		ns from 60 min

Thirteen of the 23 men exceeded the 20% F_{max} lifting criterion; seven had a mean heart rate greater than that for 30% VO_{2max} , and 14 spent more than 60 minutes at a level greater than 50% VO_{2max} . They therefore concluded that the lifting weight should be decreased and the walking time increased to remove peaks in loads.

Luttman *et al.* (1992) studied six males handling 1100 litre Eurobins after reviewing a number of studies published in languages other than English, particularly in German. These studies showed discrepancies between actual and scheduled work durations due to 'job and finish' work systems encouraging workers to complete the work as rapidly as possible and hence not take rest breaks. Luttman *et al.* Sought, firstly, to recommend a system of breaks justified by work physiology and, secondly, to calculate an 'ergonomic transportation capacity' that fulfilled the economic requirement of efficient refuse collection while protecting the health of the employees. Part of the study was reported in Jäger *et al.* (1984).

They suggested that a recovery break should be long enough for the heart rate to return to its resting level. They also noted that there is no continuity in the load during refuse collection with high loads while containers are being transported and low loads during walking or driving between collection areas.

They found work pulses of 39 and 43 bpm above resting heart rate in city centre areas / suburbs and residential areas at collection rates of 0.5 and 0.6 containers per minute respectively. They compared this to a recommended limit of 40 bpm above a supine resting heart rate, noting that their measured work pulse values were minimum values since a sitting rest heart rate was used to calculate them. They therefore recommended breaks of at least 10 minutes taken every hour. They also concluded that the ergonomic transportation capacity was between 140 and 160 containers per shift, depending on the city district and therefore recommended a nominal value of 150 containers per three man crew (driver plus two loaders).

2.2.3. Effect of changing work practices

Kemper *et al.* (1990) implemented three changes in the work routine of a group of 16 refuse collectors in order to spread the load over the working day. These were: 1) to reduce the pace of walking, both with and without bags; 2) to reduce the number of bags lifted to no more than two bags at a time; and 3) to introduce more breaks in the mornings.

Their results were confounded because during the study period there was a 15% increase in the total weights handled and a concomitant increase in the distances walked. The mean working time increased by 23 minutes. Twenty minutes of this was due to an increase in time walking while not carrying. The mean number of bags handled was reduced to 1.8 and the weight lifted per throw was reduced from 15.1 kg to 13.4 kg. The mean number of breaks increased from 2 to 3.6. After making a correction for the increase in distance and load they concluded that the pace of walking had increased while the load carried had decreased.

2.2.4. Study of actual working practices

Frings-Dresen *et al.* (1995a) carried out a field study of 116 male refuse collectors (Table 8). Collectors of refuse bags spent a substantial part of the day stooping, throwing and carrying. They also loaded for shorter periods than wheelie bin collectors. Bag collection involves

lifting smaller weights many times a day. Handling wheelie bins requires pushing and pulling larger loads less frequently. They concluded from indirect estimates of oxygen consumption from heart rate data that refuse collection by bags should be increasingly replaced with collection using wheeled containers.

Table 8. Field study of refuse collection (Frings-Dresen *et al.*, 1995a)

Collection method	No of items	Mean weight	Weight collected	Time collecting	Time on breaks	% > 30% VO _{2max}	%>1hr >50% VO _{2max}
Bags	1,500	7 kg	11,000 kg	240 min	80 min	59	55
240 litre wheelie bins	500	22 kg	11,000 kg	300-360 min	100 min	51	32
1100 litre Eurobins	120	110 kg	14,000 kg	300-360 min	80 min	33	17

2.2.5. Laboratory study of refuse collection methods

Frings-Dresen *et al.* (1995b) compared the energy expenditure in a laboratory study of three methods of refuse collection. Based on the results of the earlier field study (Frings-Dresen *et al.* (1995a) they developed typical profiles of the different tasks for the simulations (Tables 9 to 11). Using a theoretical limit of an average of 30% of VO_{2max} over a working day, they argued that collection of polythene bags is only acceptable for very short working hours and small amounts of refuse. They recommended that workers aged over 40 years should work for only 1.7 hours per day and collect only 4000 kg of bagged refuse. They therefore recommended replacing bag collections with wheeled bin collections.

Table 9. Typical weights for different methods of collecting refuse

Collection method	Typical weights
Polythene bags, in a city area and a suburb	7 kg
240 litre two-wheeled bins	22 kg
1100 litre four wheeled bins	110 kg

Table 10. Times spent in the different activities

Activity	Total duration	% time
Walking	00:00:24	26.7%
Stooping	00:00:06	6.7%
Walk, Carry & Throw	00:00:12	13.3%
Standing / operating mechanism	00:00:42	46.7%
Throwing	00:00:06	6.7%
Total	00:01:30	100.0%

Table 11. Heart rate and oxygen consumption in refuse collection (from Table 3 in Frings-Dresen *et al.*, 1995b)

Rank order	Task	Mean (SD) heart rate (bpm)	Mean (SD) VO ₂	Work load (% VO _{2max})
1	Collecting bags in a city area	121 (17)	1.53 (0.34)	44.5% (7.0%)
2	Collecting bags in a suburb	113 (17)	1.27 (0.26)	37.2% (6.9%)
3	Collecting 240 litre wheelie bins	107 (16)	1.18 (0.29)	34.1% (6.0%)
4	Collecting 1100 litre wheelie bins	100 (13)	0.97 (0.20)	28.4% (4.9%)
5	Quiet standing at rest	86 (12)	0.38 (0.08)	10.3% (1.9%)

2.3. Mechanical load on the low back

Jäger *et al.* (1984) used electromyography to examine activity of the low back musculature during handling of three types of dustbins: 110 litre plastic cylindrical bins, 120 and 240 litre plastic wheelie bins and 1100 litre metallic wheelie bins. The weights they measured for the three sizes of bins are summarised in Table 12.

They found a peak in electrical activity when the 1100 litre bins were transported across kerbs. In field studies they found that these bins were handled by both one and two workers. Estimates of lumbosacral torques showed that a single worker lifting a 1100 litre bin up a kerb could decrease the lumbar load by 33% from 360 Nm to 240 Nm by bending his knees. Where a second person was helping this value could be reduced to as little as 90 Nm, depending on the position and posture of the second person.

Table 12. Bin weights found by Jäger *et al.* (1984)

	110 litre plastic dustbin	120 litre wheelie bin	240 litre wheelie bin
Empty weight	6.5 kg	11.0 kg	17.0 kg
Mean filled weight	22.9 kg	33.3 kg	43.9 kg
SD of filled weight	6.2 kg	5.8 kg	9.0 kg

For smaller bins, EMG of the biceps brachii, deltoid, erector spinae and vastus lateralis muscles, showed that every muscle was more active during transport of a dustbin than during unloaded walking. Also, the muscular activities were very high when dustbins were transported up or down stairs.

They concluded that a second person should help transport the 1100 litre containers up kerbstones rather than a single person attempting it. They also suggested that the containers should be transported across dropped kerbs and that the size of wheels could be increased to help. Other recommendations were that moving wheelie bins or carrying round bins up and down stairs should be avoided. Their overall conclusion was that the move to wheeled bins had economic advantages but created new problems if they were transported in the same way and positioned in the same places as the 10 - 50 litre bins used previously.

de Looze *et al.* (1995) carried out a biomechanical study as part of the laboratory study of three methods of refuse collection reported by Frings-Dresen *et al.* (1995b). Using an inverse dynamic analysis they used a biomechanical model to estimate lumbar spinal loading from forces measured at the hands and the positions of anatomical landmarks measured using a VICON motion analysis system. They studied multiple variables for each of the three tasks. Details are set out in Tables 13 to 15.

Table 13. Variables studied for bag handling

Task	Throw-in height	Bag weight
Lift and throw	0.68 m	6.3 kg
		11.2 kg
	1.25 m	6.3 kg
		11.2 kg
Lift, carry 5 m and throw	0.68 m	6.3 kg
		11.2 kg
	1.25 m	6.3 kg
		11.2 kg

Table 14. Variables studied for two-wheel wheelie bins ('mini-container s')

Task	Capacity	Weight + load	Handle height
Push 0.5 m on pavement, down 0.11 m high kerb & 1.0 m on road	120 litre	11 + 22 kg	0.90 m
			1.01 m
		11 + 60 kg	0.90 m
			1.01 m
	240 litre	17 + 22 kg	1.01 m
			1.16 m
		17 + 60 kg	1.01 m
			1.16 m
Pull 0.5 m on pavement, down 0.11 m high kerb & 1.0 m on road	120 litre	11 + 22 kg	0.90 m
			1.01 m
		11 + 60 kg	0.90 m
			1.01 m
	240 litre	17 + 22 kg	1.01 m
			1.16 m
		17 + 60 kg	1.01 m
			1.16 m

Table 15. Variables studied for 1100 litre metal wheelie bins ('containers')

Task	Handle height	Empty weight + load
Push 2.0 m on pavement	1.09 m	185 + 110 kg
		185 + 200 kg
Pull 2.0 m on pavement	1.09 m	185 + 110 kg
		185 + 200 kg
Lift up 0.11 m high kerb	0.72 m	185 + 0 kg
	1.09 m	

Typical force-time curves of the estimated spinal compression from a single individual carrying out the four tasks are shown in Figure 1.

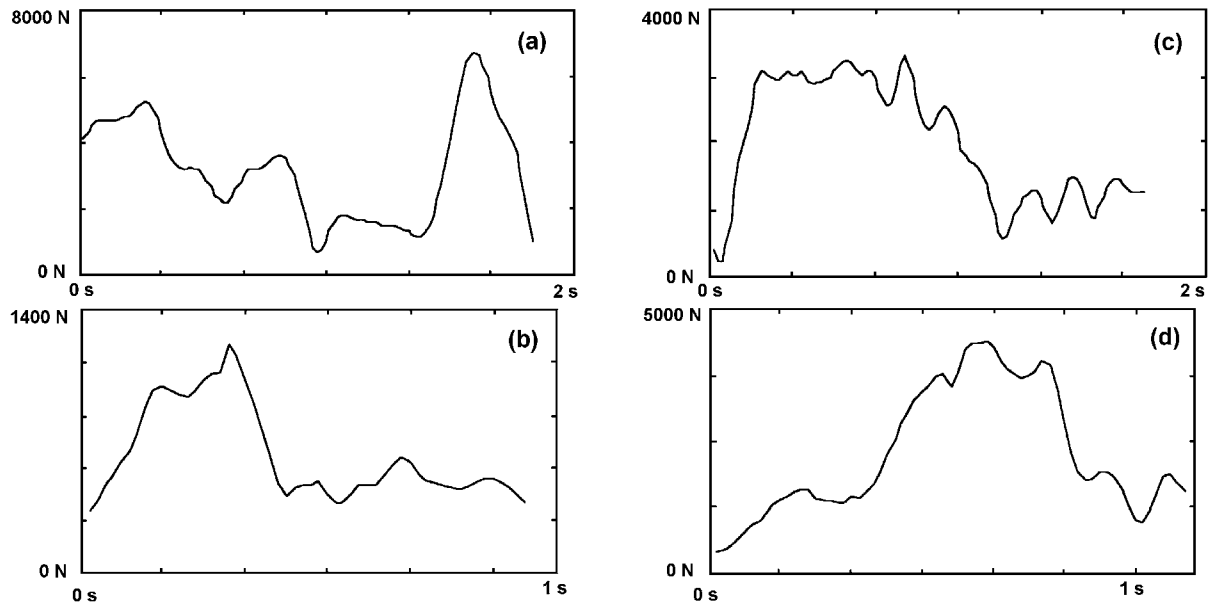


Figure 1. Estimates of spinal compression for a single subject of de Looze *et al.* (1995) for (a) picking up / throwing bags; (b) tilting / pushing a small wheelie-bin; (c) pulling an 1100 litre wheelie bin; and (d) lifting an 1100 litre wheelie bin up a kerb*

The largest peak in graph (a) was associated with the acceleration of the bags just before throwing. The actual picking up of the bags was also associated with relatively high forces. For the smaller wheelie bins (graph (b)) the peak occurred when it was tilted onto its wheels. For pushing of the 1100 litre bin, a steep increase to a peak was observed at the start of the movement (graph (c)). A large peak was observed for the action of lifting the empty 1100 litre bin up the kerb (graph (d)).

The results in Table 16 of analysis of variance of the main effects of the tasks show that the largest effect in bag handling was due to bag weight. The method of handling had a smaller effect, but the throw in height had no effect on spinal loading. For the two-wheeled bins, the filling weight significantly affected the spinal load. The method of handling and the handle height had only weakly significant effects, and the actual capacity had no effect. For 1100 litre bins, lifting an empty bin up a kerb was significantly worse than pushing or pulling a full one. For this lifting task the higher of the two handle heights produced lower spinal loads.

*Reproduced from: *Ergonomics*, Volume 38, No 10, de Looze MP, Stassen AR, Markslag AM, Borst MJ, Wooning MM and Toussaint HM, "Mechanical loading on the low back in three methods of refuse collecting", pp 1993-2006, Copyright (1995), with permission from Taylor and Francis Ltd. (<http://www.tandf.co.uk/journals>).

Table 16. Data from Table 3 of de Looze *et al.* (1995) on significance of effects on spinal loading in different methods of handling

Collection method	Factor	Measure of spinal loading	F ratio	Significance of difference	Factor causing greatest loading	
Bags	Pick up / throw or pick up / walk / throw	Compression	4.90	P<0.05	Pick up / throw	
		Shear	11.36	P<0.01		
	Bag weight 6.3 kg or 11.2 kg	Compression	29.60	P<0.001	Heavier bag	
		Shear	54.22	P<0.001		
	Throw-in height 0.68 m or 1.25 m	Compression	1.17	ns		
		Shear	2.36	ns		
120 / 240 litre wheelie bins	Tilt / push or tilt / pull	Compression	5.42	P<0.05	Tilt / pull	
		Shear	1.10	ns		
	120 litre or 240 litre	Compression	1.51	ns		
		Shear	4.40	ns		
	Filling weight 22 kg or 60 kg	Compression	15.36	P<0.001	Heavier weight	
		Shear	22.17	P<0.001		
	Handle height 0.90 m, 1.01 m or 1.16 m	Compression	1.51	ns	Lowest handle	
		Shear	4.40	P<0.05		
	1100 litre wheelie bins	Push, pull or lift	Compression	74.00	P<0.001	Lifting empty container worse than pushing / pulling full ones
			Shear	19.96	P<0.001	
Filling weight 110 or 200 kg; 0 kg for lifting		Compression	0.73	ns		
		Shear	0.80	ns		
Handle height 0.72 m or 1.09 m for lifting		Compression	24.38	P<0.001	Lower handle height	
		Shear	59.54	P<0.001		

Table 17 shows that, on average, each refuse collector will handle approximately 800 bags per day. Approximately 75% of these will be carried towards the truck and thrown in and the remainder will be picked up near the truck and thrown straight in. Where wheelie bins are concerned they are as likely to be pulled as to be pushed. The large 1100 litre bins are handled much less frequently in a shift and are slightly more likely to be pulled rather than pushed. Lifting them up kerbs is actually a very rare event. This presumably reflects refuse collectors deliberately avoiding doing this very heavy task unless absolutely necessary by making use of features of the pavements such as ramps and dropped kerbs.

**Table 17. Daily number of events for the three methods of refuse collection.
Data from Table 4 of de Looze *et al.* (1995)**

Collection method	Activity	Mean events per working day
Bags (n=15)	Pick up	807
	Stand / throw in	220
	Walk / throw in	587
120/240 litre wheelie bins (n=47)	Tilt and push	490
	Tilt and pull	518
Large containers (n=18)	Push	103
	Pull	134
	Lift	3

de Looze *et al.* (1995) noted that refuse collection is characterised by short bursts of activity, some of which involve high peak forces on the lumbar spine. However, the frequency of exposure to these forces varies greatly between the different collection methods. They argued that, because of the magnitude and frequency of the peak forces, the bags method should be discouraged. They noted that the peak during lifting exceeded the NIOSH Action Limit in the majority of trials, and that they had restricted movements to the sagittal plane in order to be able to use their dynamic two-dimensional linked-segment model. In reality, throwing of bags is accompanied by considerable spinal twisting and asymmetric loading.

No significant differences in spinal loading were found between the two throw-in heights. They tested the difference in net moments at the shoulder, and reported (without presenting data) that they were significantly lower at the lower- throw in heights.

Handling of mini-containers produces significantly smaller forces than the bags method, with the NIOSH Action Limit not being reached, for a smaller number of events. Therefore, they recommended replacing bags by wheelie bins wherever possible.

Pulling of full 1100 litre containers resulted in spinal compression above the NIOSH Action Limit. The main difference between this method and the others was the much lower frequency of handling. They therefore argued that it was another possible alternative to bags, especially if the highest peaks could be eliminated by removing the need to lift containers up kerbs by lowering the kerbs, and by making the task a two-man operation.

Jäger *et al.* (2000) reported an analysis of total daily lumbar load using a dynamic biomechanical model, for a number of tasks, including refuse collection. Using measurements of approximately 50 bins, they estimated that horizontal pushing or pulling forces for moving

wheelie bins are 13% of the bin weight. They found that an individual emptied 1007 bins in a shift, with a mean weight of 20 kg, 10th and 90th percentiles of 11 and 33 kg and a maximum of 97 kg. They found that the transportation and emptying conditions of dustbins varied considerably, leading to diverse patterns of lumbar loading.

Schibye *et al.* (2001a) compared the mechanical load on the low back and shoulders during pushing and pulling a 240 litre two-wheeled refuse bin with the load during lifting and carrying the same load in bags and bins. They used a three-dimensional force transducer to measure the forces on the handle of the wheelie bin and a motion analysis system and a biomechanical model to estimate the forces inside the body. The bin was loaded with 25 or 50 kg. The paper bag and the 6 kg, 100 litre, plastic dustbin were loaded with 7 kg or 25 kg. Subjects lifted the bag or dustbin onto their backs without any constraints on technique.

During pushing the force at the hands (Table 18) was directed downwards-backwards in the tilting operation and downwards-forwards during the initial and sustained phases of the actual push. During pulling the tilting force was downwards-forwards and upwards-forwards in the following pull operations (Figures 2, 3, 4). The direction of force was hardly affected by increasing the weight in the wheelie bin from 25 to 50 kg. However, the magnitudes of the resultant and horizontal force did increase. The forward inclination of the trunk was greater in the initial phase than in the sustained phase of all movements. It was the same for pushing and pulling but increased when the load was increased from 25 to 50 kg. The net torque at L4/L5 was generally small and not affected by an increase in the weight of the container. The largest values occurred during tilting before pulling and the values in the initial phase were larger than the values during the sustained phase.

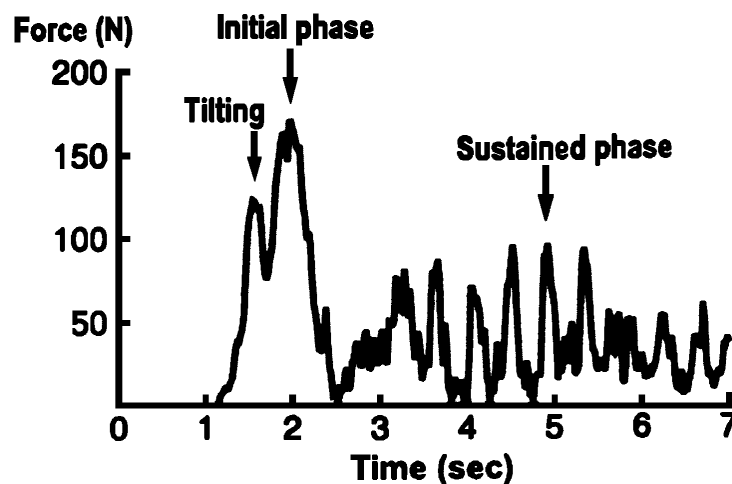


Figure 2. Fig 2. from Schibye *et al.* (2001a), an example resultant force trace from a pushing operation*

The compressive forces during lifting bags and dustbins were much greater than at any point during pushing and pulling. However, the loads during carrying 25 kg on the back were comparable to those during pushing and pulling 25 kg.

*Reproduced from: *Clinical Biomechanics*, Volume 16, No 7, Schibye B, Sogaard K, Martinsen D and Klausen K, "Mechanical load on the low back and shoulders during pushing and pulling of two-wheeled waste containers compared with lifting and carrying of bags and bins", p 552, Copyright (2001), with permission from Elsevier Science Ltd.

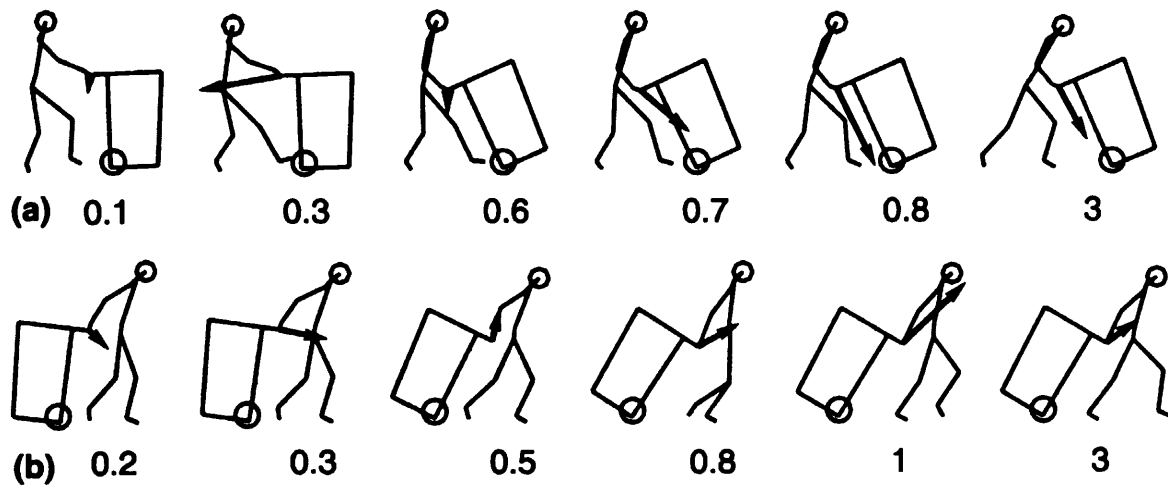


Figure 3. Fig. 3 from Schibye *et al.* (2001a), showing the sequence of events during (a) pushing and (b) pulling. The numbers denote time from the onset of the operation and the arrows indicate the size and direction of resultant forces*

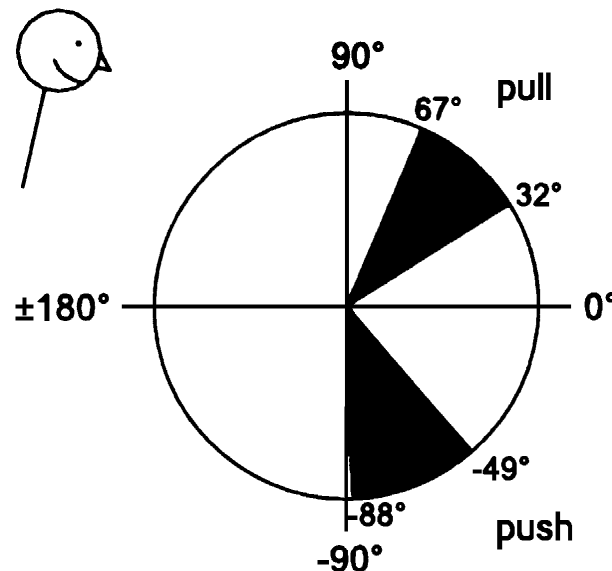


Figure 4. Fig. 4 from Schibye *et al.* (2001a): Directions of resultant forces in the initial and sustained phases of pushing and pulling a 240 litre wheelie bin*

They concluded that, during pushing and pulling, the compression force at the L4/L5 disc was between 400-1600 N, never exceeding the 3400 N limit used by NIOSH. This was also the case during standing with a full paper bag or bin on the back, but the compressive force could exceed this limit during lifting of the bag or bin. They attributed the difference between lifting and standing to differences in back muscle activity and noted that during pushing and pulling an extension torque counteracts the flexion torque produced by gravity on the forward leaning upper body. However, during lifting, the weight of the trunk and the bag combine to produce a much larger flexion torque.

*Reproduced from: *Clinical Biomechanics*, Volume 16, No 7, Schibye B, Sogaard K, Martinsen D and Klausen K, "Mechanical load on the low back and shoulders during pushing and pulling of two-wheeled waste containers compared with lifting and carrying of bags and bins", p 552 - 553, Copyright (2001), with permission from Elsevier Science Ltd.

Table 18. Forces at the hands when handling a 240 litre wheelie bin (from Table 1 of Schibye *et al.*, 2001a)

Phase	Method	Weight kg	Direction °	Push/pull force N	Horizontal force N	Trunk forward inclination °
Tilting	Push	25	-153	118	99	10
		50	-167	222	211	6
	Pull	25	-44	138	70	29
		50	-20	201	181	31
Initial	Push	25	-69	219	74	23
		50	-64	276	115	28
	Pull	25	44	179	127	24
		50	43	242	172	25
Sustained	Push	25	-66	98	39	15
		50	-66	133	53	23
	Pull	25	56	111	62	16
		50	48	142	95	19

0° = horizontal forwards, ±180° = horizontal backwards, 90° = vertical upwards, -90° = vertical downwards; Values are means from seven subjects

2.4. Pushing and pulling

van der Beek *et al.* (1999) cited a study reported in Dutch by Hoozemans *et al.* (1996) that showed that varying the height of the centre of gravity of a two-wheeled dustbin changed the vertical forces necessary for pulling and pushing them. The horizontal force needed was not affected. They also cite a study by Donders *et al.* (1996) (also in Dutch) which showed that variations between subjects accounted for 80% of variations in pushing and pulling forces of wheeled dustbins. They therefore hypothesised that the personal working technique is of great importance in pushing and pulling of MMH aids and suggested that experienced workers would exert the pulling force in a more efficient direction. Presumably the variation is also partly accounted for by variations in the handle heights and therefore in the angles of the bins that the subjects chose when performing the tasks.

Laursen and Schibye (2002) investigated the forces involved in pushing and pulling 240 litre wheelie bins on flagstones, paving stones, and grass. In the sustained phase of a push or pull the largest hand forces occurred on grass and the smallest on flagstones. Only small components of force occurred outside the movement plane. The trunk inclination increased as the magnitude of the vertical force component increased but was not related to the horizontal component.

Generally they found that push and pull forces were comparable in both the tilting and initial phase of the pull / push, but that sustained pushing forces were greater than sustained pulling forces. They attributed this to the downward force required to push increasing the rolling resistance whereas the upward force of pulling would decrease it. Balancing a two-wheeled container creates additional restrictions on the force vector and on the posture adopted, but these stability requirements did not seem to cause any particular load on the lumbar spine. Also, they reported that the overall biomechanical load was low when compared to a task such as lifting.

2.5. Effects on health and fitness / survival in the job

2.5.1. Psychosocial factors

Lund *et al.* (2001) attempted to test the hypothesis that early retirement / long-term unemployment is influenced by psychosocial factors such as low decision authority, low skill discretion and high ergonomic exposures. Of a cohort of 2618 Danish male refuse collectors and municipal workers carrying out physically heavy outdoor work 24.9% left their job in the following 2.5 years. Of these, 31% were in another job, 15.6% were unemployed, 10.3% were receiving disability pensions or long-term sickness benefit, and 12.1% were receiving early retirement pensions. They found that the factors affecting selection out of the job were the physical and psychosocial work environment factors of self-rated 'extreme bending of the back', low skill discretion and low decision authority. Unemployment was also associated with pushing of heavy loads and extreme bending of the back. They suggested that ergonomic improvements in the work environment could potentially decrease the number of people becoming unemployed.

2.5.2. Physical capacity of refuse collectors

Schibye *et al.* (2001b) investigated whether waste collection had a training effect or deleterious 'wearing' effect on the workers' physical capacity. They compared young and old groups of refuse collectors with age-matched control groups without physically heavy work. The older refuse collector group was significantly heavier and had significantly higher Body Mass Index (BMI) than the aged control group. The two younger groups did not differ on height, weight, or BMI.

They found that both elderly groups had 30% lower maximal oxygen uptake than the young workers, corresponding to a 1% annual decrease in VO_{2max} independent of job type. Since the older workers were heavier, the weight related VO_{2max} decreased even more, by 40%. Using the assumption that the elderly workers initially had the same aerobic capacity as the younger workers, they concluded that there was no training or wearing effect due to waste-collection work when compared with non-physically heavy work. Because of the obesity of the older waste collectors they argued that it was necessary either to reduce the work load on them or to increase their fitness by specific aerobic training and weight loss.

There was a general tendency to greater muscle strength in the working groups compared to the controls, which could be interpreted as a training effect. Shoulder abduction strength was 45% greater in the elderly working group than the elderly control group. However, they noted that other studies had found that a physically heavy job is no guarantee of high muscle strength. They also argued that the generally higher capacity found among younger waste collectors might, alternatively, indicate a healthy worker selection effect taking place within the first few years of doing the job. If this was so, then it seemed to be based on muscle strength, particularly shoulder strength, not aerobic capacity.

2.6. Job rotation

Kuijer *et al.* (1999) investigated the effect of job rotation on physical workload in refuse collection in Holland. Four groups of four workers were studied who undertook different combinations of refuse collection and street sweeping (Table 19).

Table 19. Combinations of jobs studied by Kuijer *et al.* (1999)

Group	Tasks
RR	Solely refuse collection
SS	Solely street sweeping
RS	Refuse collection alternating on half shift basis with street sweeping
SD	Street sweepers alternating on half shift basis with driving

They measured energetic load by measuring heart rate over the working day and by manually coding trunk posture every 15 seconds. They found that job rotation had no effect on the intensity with which the task was performed but decreased the perceived load and the energetic load. The postural load of the trunk was less for street sweepers than for refuse collectors, but perceived fatigue and exertion did not differ. This was attributed to either a more heterogeneous physical workload or to psychological factors making the job with rotation less monotonous and reducing the perceived load.

2.7. Long term effects of changes in working patterns

Kuijer *et al.* (2000) compared the workload of a group of Dutch refuse collectors ('Study III') with the results of two earlier studies. The first had been carried out on the same workforce ('Study I', Kemper *et al.*, 1990) and the second was a national study ('Study II', Frings-Dresen *et al.*, 1995a) which resulted in guidelines (Frings-Dresen *et al.*, 1995b) which had been implemented not long before the study. The amount of refuse collected in bags did not differ between the three studies. In Study III more two-wheeled bins were handled and more refuse collected per minute than in Study I or Study II.

They concluded that the energetic workload had not been reduced compared to the original study 12 years previously, nor did it differ from the national study and therefore that refuse collection can still be classified as heavy physical work despite the changes made. However, the perceived exertion was lower and the postures were more favourable in the latest study. The one additional difference was that a recycling scheme had been implemented with 'grey' and 'green' refuse being collected on alternate weeks. Since all the measurements had been made on grey weeks, and the level of recycling was not known, there may be differences between the workloads for the different types of collection.

3. METHODS

3.1. Introduction

3.1.1. *Systems of refuse collection*

The local authority that had been identified as willing to co-operate with the study proved to be a suitable location for evaluating manual handling of refuse using a variety of methods and working practices for refuse collection. For normal domestic waste, some areas have a service where black bags are collected every week, between Monday and Friday. Other areas have wheelie bins that are collected weekly. Some areas have grey wheelie bins for ordinary refuse and green wheelie bins for recyclable refuse. These are collected on alternate weeks. The recycling service does not include glass or newspapers and householders are encouraged to take these to receptacles in supermarket car parks.

The terrain in this city varies from flat to hilly. Also, some older houses are built with doors opening directly onto the street and with a long alley running behind the houses along the length of the street. Access is often only via the ends of these alleys. In these circumstances the householders are expected to leave rubbish bags in the alley by their back gate. The refuse collectors carry the bags from the gates to the end of the alley where the truck is waiting.

All refuse collection vehicles belonging to the local authority are fitted with lifting gear to enable the mechanical emptying of wheelie bins into the vehicles. Each vehicle, including those used for recycling rounds, also has a mechanical compactor fitted at the rear to reduce the volume of the waste loaded into it. When bags are collected they have to be thrown over the bin lifters and a bar at the back of the vehicle designed to stop the refuse falling back out. This bar is known as a 'rave bar' or 'rave rail' and its height as the 'rave height'.

3.1.2. *Domestic rounds*

The domestic rounds in this city all start at 6:00 AM. A system of 'job and finish' allows a crew to go home once they have completed their round. As a result, the crews work as quickly as possible and tend to skip breaks to finish the job early. The 6:00 AM start is enforced by the keys to the vehicles being held at the depot overnight and not handed out until that time. Crews have adopted a number of practices to allow them to get ahead on the collection and to make their lives easier. Thus, it was normal for not all the crew to report to the depot at either the start or end of the shift, but some would meet the vehicle part way through the round and be dropped off at the end. This was especially so if their homes were between the start or finish of the round and the depot since this saves them travelling to the depot. As a result, some would go to the start of the round well before 6:00 AM and start gathering bags into piles ready for collection by the crew members accompanying the vehicle.

3.1.3. *Trade round*

A trade round operates from 12:30 PM on Mondays to Fridays to collect refuse from businesses in the city. This is a service where the business pays according to the level of service, with large businesses would have daily collections, whereas small ones might only have a weekly collection. A number of commercial firms also provide a business refuse

collection service in competition with the local authority. The round varies from day to day and it would be unusual for the crew to work along a street collecting from all the premises on it since locations can be quite far apart. Since many of the businesses are in the city centre the crew need to time the round carefully to avoid evening rush hour traffic jams. Refuse is collected in both bags and wheelie bins. The large green ‘trade sacks’ were of a heavier and grade of plastic than typically found in domestic black bags. Three sizes of bins were in use: 1100 litres (‘Eurobins’), 360 litres and 240 litres.

3.1.4. Other methods of refuse collection

A variety of other refuse collection methods exist in different parts of the country, including the use of so-called ‘Paladin’ bins. These are large cylindrical metal wheeled bins used for refuse in commercial premises and multi-occupancy dwelling, such as blocks of flats. They are usually located underneath refuse chutes.

Paladin bins are seen as being very heavy to move and difficult to manoeuvre. Other problems are that they have a relatively small wheelbase and high centre of gravity and are therefore likely to topple over, especially on slopes. They are perceived as being bulky, unsightly and potentially unhygienic, as attracting fly tipping and being noisy due to their metal construction. They are also difficult to load onto the lifting mechanism on the rear of the lorry. A special clamp is required on the lifting mechanism due to the round shape of the Paladin bin. This therefore makes it difficult for the same vehicle to deal with ordinary wheelie bins and Paladins. There is a general tendency to phase them out by replacing them with the 1100 litre ‘Eurobins’ though some local authorities have replaced manual handling of Paladins with crane emptying of much larger underground containers.

3.2. Details of the refuse collection rounds studied

HSL staff followed three refuse collection rounds on the Thursday afternoon and the Friday morning. The main details of these rounds can be seen in Table 20. At that time of year sunrise is approximately 08:00 and sunset 16:00. HD and FOD staff had followed a bags round earlier on the Thursday.

Table 20. Details of the rounds studied

	Round A	Round B	Round C
Type of round	Bags	240 litre green wheelie bins for recyclable material. Grey (ordinary refuse) and green weeks alternate.	Trade bins (240, 360 and 1100 litre sizes) plus green trade bags and loose refuse.
Number in crew	5	4	2
Round start time	06:00	06:00	12:30
Round duration	8.5 to 9 hours	6.5 to 8 hours	6.5 to 7.5 hours
Start and finish of round following	06:00-09:00 8 Dec.	09:30-11:30 8 Dec.	15:30-18:00 7 Dec.
Weather	Dry, still, cold, bright sunlight from dawn	Dry, still, cold, bright sunlight from dawn	Heavy rain, wind, cold
Heart rate monitoring	Two loaders	Two loaders	Both driver and loader

3.3. Measurement of bag weights

Bag weights were recorded during a 1 hour 20 minute period of one round using a Mecmesin force dynamometer. A large hook fitted to the dynamometer was used to lift the bags and measure the weights in kilograms. This was done by going ahead of the crew and weighing most of the bags left on the pavement by the householders. Weights were recorded by one person lifting the bag with the dynamometer and the other person videoing the display (Figure 5). The bags were then dropped to the ground again for collection. On return to the laboratory the weights shown on the display were transcribed from the video.



Figure 5. Weighing of bags with a Mecmesin dynamometer

3.4. Heart rate monitoring

Heart rates were recorded using Polar Heart Monitors, model Vantage NV (Finland, Polar Electro Oy). These consist of a signal detector and transmitter worn around the chest and a wrist watch that picks up, displays and stores the signal. Sweat bands were worn over the watches to protect them from damage. Heart rates were measured for six subjects across three rounds. The watches were initially set to record the mean heart rate every five seconds, though one subject manually set his watch to record every heart beat with the result that the watch only recorded 40 minutes of data for him. After retrieval from the subjects, the data were downloaded from the watches to a computer for analysis using Polar software (Polar Precision Performance v2.1, 1999: Finland, Polar Electro Oy).

3.5. Postural analysis

Video was used as the primary means of recording posture data and work rates. The video was analysed using Observer Pro software. Working posture was broken down into the categories provided by the OVAKO Working Posture Analysis System (OWAS). The first part of the analysis coded changes in the back, arms, and leg postures adopted, the manual handling operations being carried out and the loads being handled. The second part used these data to examine the frequency, relative times and mean durations of particular postures or manual handling operations.

Video was taken of three rounds using a pair of Panasonic Mini DV cameras. The typical process was for two observers to follow the refuse truck in a car. As appropriate one observer followed on foot taking video or still photographs while the other drove the car. Filming concentrated on the periods when rubbish was actively being collected and loaded into the vehicle. Therefore, periods when the crew were travelling between locations where rubbish was to be collected were generally not filmed. It is therefore impossible to draw conclusions from the films about the proportion of time usually spent collecting rubbish and the proportion spent in travelling.

Because of the time of day and year much of the footage was shot during the hours of darkness. Therefore, much of the footage is dependent on artificial sources of light such as street lighting and the headlights of the observers' car. However, the high visibility clothing worn by the crews helped locate and identify them. Heavy rain on the first day added to the problems of visibility.

The nature of such a process of videoing is that activities of interest are filmed. Therefore, the cameras were often panned to follow an individual as he collected sacks or wheelie bins and brought them to the truck. With a crew of four or five it is impossible to capture every event with only two cameras, even if the filming did tend to concentrate on the back of the truck where all rubbish was brought. Therefore, individuals are not seen on the tape for extended periods and appear and disappear from it. Also, when several individuals were gathered round the back of the truck to throw rubbish in they would often obscure the camera's view of other individuals.

3.5.1. Posture coding

Video was coded using the OWAS system (Karhu *et al.*, 1977, 1981, Vedder, 1998). This was done using the Observer Pro video analysis system (Noldus Information Technology BV, Wageningen, The Netherlands). This provides precise control of the video tape (Carey and Gallwey, 1998) while postures were being coded. V4.0 of the Observer Support Package for Video Analysis was used on an IBM compatible PC running Windows NT. The video was digitised to MPEG-1 format using a Broadway Pro card and the digitised file was played back through the Observer software.

The Observer software was set up for 'Focal Sampling'. This is a real time method of coding with defined events being coded at the point of their occurrence. It is therefore possible to measure the duration of a particular action and identify if sequences of events recur. Subjects were defined to correspond to each member of the crew being videoed. Four Behavioural Classes were defined corresponding to the three body parts and the force level category that are classified in the OWAS system. An additional Behavioural Class was defined to allow a more meaningful classification of the handling operations occurring. This permitted distinction between lifting, lowering, pushing, pulling, carrying and throwing.

Within each Behavioural Class, Elements were defined corresponding to each of the postures for the corresponding body part. Within the Rubbish Behavioural Class, Modifiers were used to allow a description of the number of hands being used, the type of refuse being collected, and whether a bin was full or empty. A 'no entry' element was also defined for each body part. Each Element was assigned to a different keystroke to allow rapid coding via the

computer keyboard. This combination of Subjects, Behavioural Classes and Elements allowed each of the subjects being observed to be coded separately for the duration of the video. The Behavioural Classes and Elements are listed in Table 21:

Table 21. Assignment of postures to Behavioural Classes / Elements

Behavioural Class	Element	Modifier 1	Modifier 2	Definition	
Back	Straight			Trunk upright and not rotated	Default
	Bent			Trunk flexed	
	Twisted			Trunk rotated	
	B&TW			Trunk flexed and rotated	
	No Back			Trunk not visible	
Arms	2 Below			Both arms below shoulders	Default
	1 Above			One arm above shoulders	
	2 Above			Both arms above shoulders	
	No Arms			Arms not visible	
Legs	Sitting			Both legs unloaded	Default
	Stand2			Loading on both legs, knees straight	
	Stand1			Loading on one leg, knee straight	
	2 Bent			Loading on both legs, both knees bent	
	1 Bent			Loading on one leg, knee bent	
	Kneel			Kneeling on one or both knees	
	Walk			Body being moved by the legs	
	No legs			Legs not visible	
Load	<10 kg			Load < 10 kg	Default
	<20 kg			Load between 10 kg and 20 kg	
	>20 kg			Load > 20 kg	
	Missing			Load not visible	
Rubbish	No load	None		No manual handling	Default
	Lift	Hands	Bags no	Lift rubbish bag	
	Lower	Hands	Bags no	Lower rubbish bag to ground	
	Carry	Hands	Bags no	Carry / hold rubbish bag	
	Throw	Hands	Bags no	Throw bag into truck	
	Push	Hands	Bin state	Rounds A/B push wheelie bin	
	Pull	Hands	Bin state	Rounds A/B pull wheelie bin	
	Push	Bin size	Bin state	Round C push wheelie bin	
	Pull	Bin size	Bin state	Round C pull wheelie bin	
	Not seen	None		Rubbish out of view	
Hands	Left			Action by left hand only	
	Right			Action by right hand only	
	Both			Action by both hands	
Bags no	1-6			Number of bags held by a hand	
Bin size	240 litre			240 litre wheelie bin	
	360 litre			360 litre wheelie bin	
	1100 litre			1100 litre Eurobin	
	Dustbin			Standard dustbin	
Bin state	Full			Bin contains refuse	
	Empty			Bin empty of refuse	

Coding started either at the start of the video or at a point where sufficient light was available to allow individuals' postures to be observed and coded. Where necessary, the file was stepped through frame by frame. Due to the difficulty of knowing the load at the hand it was always coded as less than 10 kg. Missing codes were entered when workers were not visible.

3.5.2. Assignment of postures to OWAS Action Categories

The WinOWAS software (Tampere University Technology, Occupational and Safety Engineering, 1996) implements an algorithm that assigns Action Categories using the percentage of time that a person spends with a body part in a particular posture. This allows different degrees of severity to be assigned to the same posture, depending on the proportion of the time that is spent in any particular posture. It is therefore a substantial refinement of the original classification system (Karhu *et al.*, 1977) which assigned postures to Action Categories irrespective of whether they were frequently adopted or only rarely adopted. The meanings of the different Action Categories were given in Table 22. The postures, percentages of time and associated Action Categories are listed in Table 23.

Table 22. OWAS Action Categories

Action Category	Meaning	Action required
AC 1	Normal posture	No action required
AC 2	Slightly harmful posture	Action required in the near future
AC 3	Distinctly harmful posture	Action required as soon as possible
AC 4	Extremely harmful posture	Action required immediately

Table 23. Percentages of time in a posture and OWAS assignments to Action Categories

Body part	Posture	AC 1	AC 2	AC 3	AC 4
Back	Straight	0-100%			
	Bent	0-30%	30-80%	80-100%	
	Twisted	0-20%	20-50%	50-100%	
	Bent and Twisted	0-5%	5%-30%	30-70%	70-100%
Arms	Both below shoulder	0-100%			
	One below shoulder	0-30%	30-80%	80-100%	
	Both above shoulder	0-20%	20-70%	70-100%	
Legs	Sitting	0-90%	90-100%		
	Standing on two legs	0-80%	80-100%		
	Standing on one leg	0-30%	30-80%		
	Standing on two bent knees	0-5%	5-30%	30-70%	70-100%
	Standing on one bent knee	0-5%	5-30%	30-70%	70-100%
	Kneeling	0-20%	20-50%	50-100%	
	Walking	0-80%	80-100%		
Load	< 10 kg	0-100%			
	< 20 kg	0-100%			
	> 20 kg	0-100%			

4. RESULTS

4.1. Results of posture analysis

4.1.1. Introduction

In interpreting the following charts the limitations of the videoing and coding processes must be remembered. It was not possible in the time available to ensure that the video shot was systematically representative of all refuse collection activities of the area, or even of the rounds followed. The location was chosen because it had a mixture of collection methods. Therefore, the situation in localities where only single methods are used will differ. Also, there are other systems of refuse collection such as the use of Paladin bins that do not occur here, and variants of the methods observed, such as the distribution of black bags to households.

The video was shot by following rounds that represented the range of collection methods in use by the local authority. This was done for 2-3 hours per round over a two day period in early December. The choice of different days of the week or a different time of year might have affected the activities observed. This was particularly clear with the green bins round where the crew stated that they collected significantly more refuse on a grey week.

The actual video recorded depended upon what the persons with the video cameras could see. Most was shot from a car following the round so tended to concentrate on activities at the rear of the truck and those activities occurring near the truck such as carrying bags, pushing full bins onto the bin lift and pulling empty ones from it. It was far less likely to capture more distant activities such as removing black bags from dustbins or collecting them from house boundaries or collecting and returning wheelie bins from and to storage locations. While several members of a crew of four or five might be visible at the rear of the truck on a number of occasions, inevitably individuals would appear and rapidly disappear from view. If an attempt was made to follow an individual with the camera then the activities of the others would almost certainly be missed while this was happening.

Also, because of the time of year, much of the video was taken after nightfall on the first day and before dawn on the second. While the video cameras can adapt to a wide variety of light levels, inevitably the picture quality is much poorer than would have been obtained in bright sunlight in the summer. There tend to be highlights within the pictures depending on the positioning of street lamps, head lamps and the reflective high-visibility clothing worn by the refuse collectors. Therefore, the amount of usable video for each round was relatively short.

Because it was decided to adopt a posture coding method it was possible to code when postures changed from one category to another (e.g., from trunk straight to trunk bent). This allowed the Observer software to calculate durations of postures. As five Behavioural Elements were defined, this process was labour intensive and therefore coding from video was essential. Despite various attempts within the ergonomics community to devise checklist / diagrams / portable computers for posture coding, accurate coding in real time is effectively impossible, especially if more than one code is being recorded. Using digitised video with The Observer provides the ability to move instantaneously to any point and to view the video repeatedly frame-by-frame, at almost any speed, and in either direction. These features allow

the coder to avoid information overload, to process information at a speed consistent with human abilities, to time events accurately, to extract multiple items of information from a single frame, to determine from a sequence of frames the nature of an action when this might be ambiguous in a single frame, and to correct errors. However, the coding process is still prone to error because of a number of factors. Firstly, it involves deciding what constitutes a particular posture or activity. Secondly, the coder may not be able to maintain concentration sufficiently to code completely accurately. Thirdly, individuals may be partly obscured by other objects or because of the angle of view or the object being handled so that their actions may not be completely certain. Fourthly, the postures being coded are not precisely defined, so that the boundary between a straight back and a twisted back is not defined and therefore may depend on the judgement of the coder.

Because of all these considerations it is necessary to describe the posture coding as at best indicative. Therefore, strong inferences must not be drawn from small differences between classes or between rounds. However, despite these limitations, it is believed that useful information has been obtained by the videoing and coding processes.

Table 24 gives start and finish times of the video recorded. From the length of video and the elapsed time the percentage of possible time filmed has been calculated. Film segments ranged in length from nearly two minutes to nearly 25 minutes. The elapsed time between the start and end of a film segment ranged from under five minutes to nearly 1 hour 25 minutes. The percentage of time filmed ranged from 7.7% to 67.9%. There was overlap between film shot on the same round because two cameras were in use, and on occasions the same events were visible in both videos.

Table 24. Details of video recorded (times are in hh:mm:ss)

Round	Film	Date	Start	Finish	Elapsed time	Film duration	% time filmed	Coded?
A (Bags)	A	8/12/2000	06:59:22	07:36:01	00:36:29	00:24:46	67.9%	Yes
	B		06:59:32	07:04:18	00:04:46	00:01:52	39.2%	Yes
	C		07:52:06	09:12:55	01:20:49	00:23:28	29.0%	No
B (Green bins)	A	8/12/2000	10:28:13	11:53:07	01:24:54	00:11:16	13.3%	Yes
	B		10:45:25	10:57:07	00:11:42	00:04:22	37.3%	No
C (Trade bins / sacks)	A	7/12/2000	14:59:54	17:10:14	02:10:20	00:22:46	17.5%	Yes
	B		17:16:31	18:07:56	00:51:25	00:18:20	35.7%	Yes
	C		14:56:44	17:21:17	00:24:33	00:01:53	7.7%	No

4.1.2. Trunk postures

Figure 6 shows the number of times that changes of back posture were coded. They are coded as the posture that was being adopted rather than the one being left. Therefore, between 50 and 70% of changes of back posture were into upright, straight, postures. Under 15% were into bent and twisted postures. Between 10 and 30% were into bent postures, and the remaining 8 to 15% were into postures where the trunk was twisted but not bent.

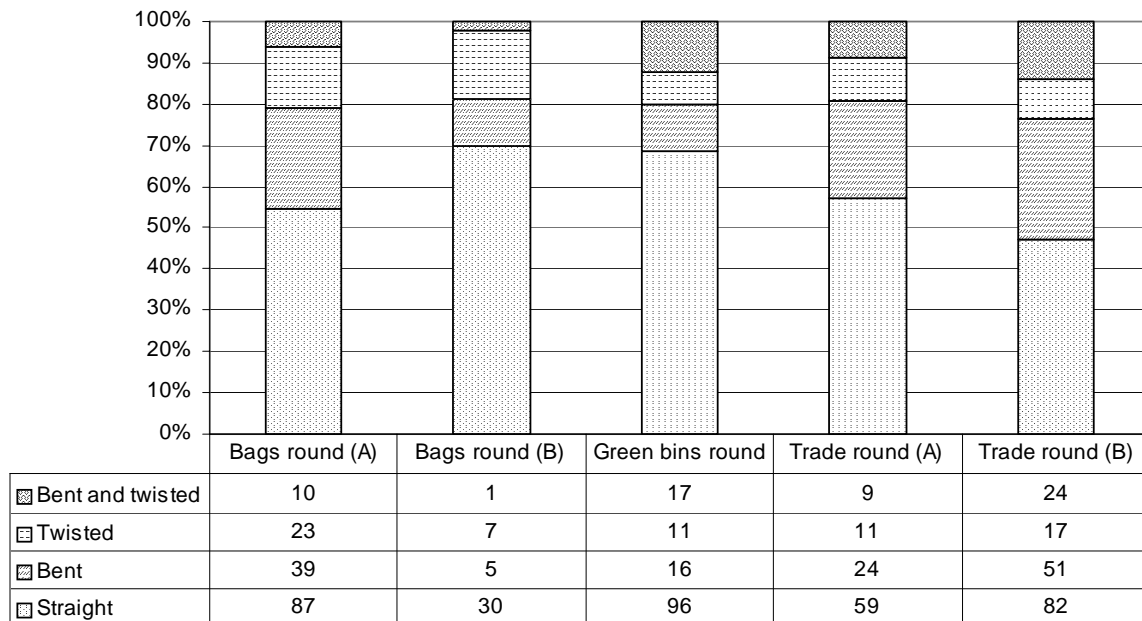


Figure 6. Occurrences of different trunk postures

Figure 7 shows how the actual time spent in the different back postures varied across the five segments of video coded. The refuse collectors spent between 78% and 89% of the time they were visible with their trunks straight, i.e., vertical. There were 9% differences between the two segments from the bags round and the two segments from the trade round. As a result, there were variations in the amounts of time spent in bent, twisted, and bent and twisted postures. Overall then, it can be concluded that refuse collectors spent between 10 and 20% of their time when actually handling rubbish (not driving in the truck between locations or back to the depot) in non-ideal (i.e., bent and/or twisted) trunk postures.

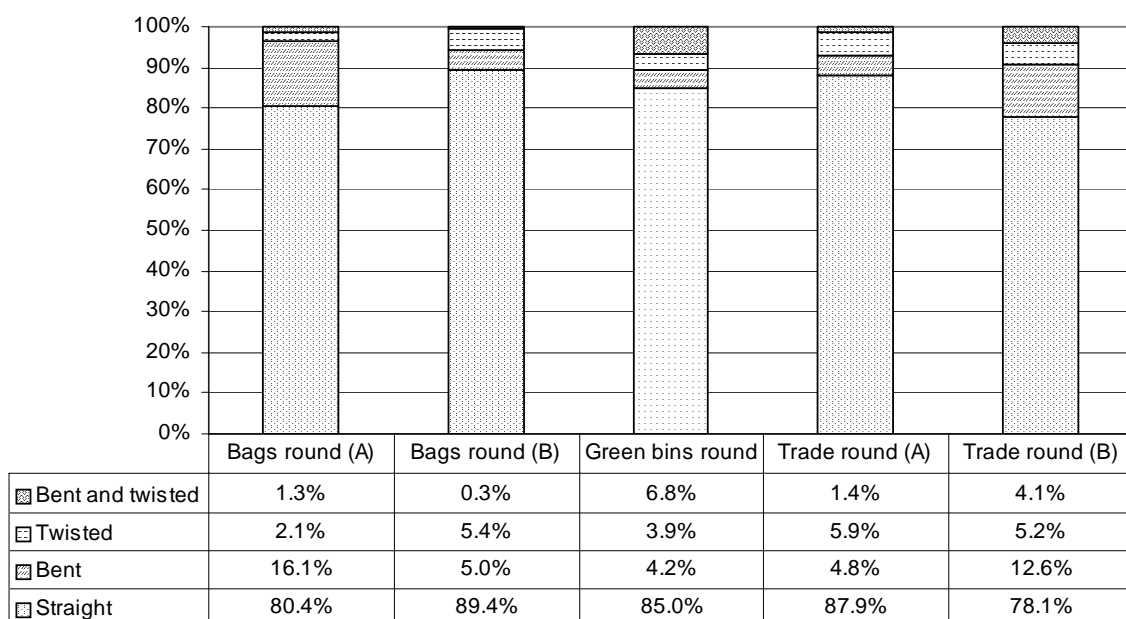


Figure 7. Posture of trunk (percentage of time visible)

Figure 8 shows the mean time in seconds spent in each trunk posture. The values for straight postures of between 5.3 and 13 seconds will be underestimates since most of the time when individuals were not visible on camera they will have been walking to and from the truck. Mean times in bent postures ranged between 1.7 and 3.0 seconds; in twisted postures between 0.7 and 4.7 seconds; in the combined bent and twisted postures 0.5 and 3.9 seconds. From this it can be concluded that, in general, only relatively brief periods are spent in the non-ideal trunk postures, though the times spent in twisted postures were greater in rounds involving handling wheelie bins. This probably reflects a tendency to adopt twisted postures when pulling and pushing bins, especially if done one-handed. The bent, and bent and twisted postures were almost exclusively associated with lifting bags from the ground.

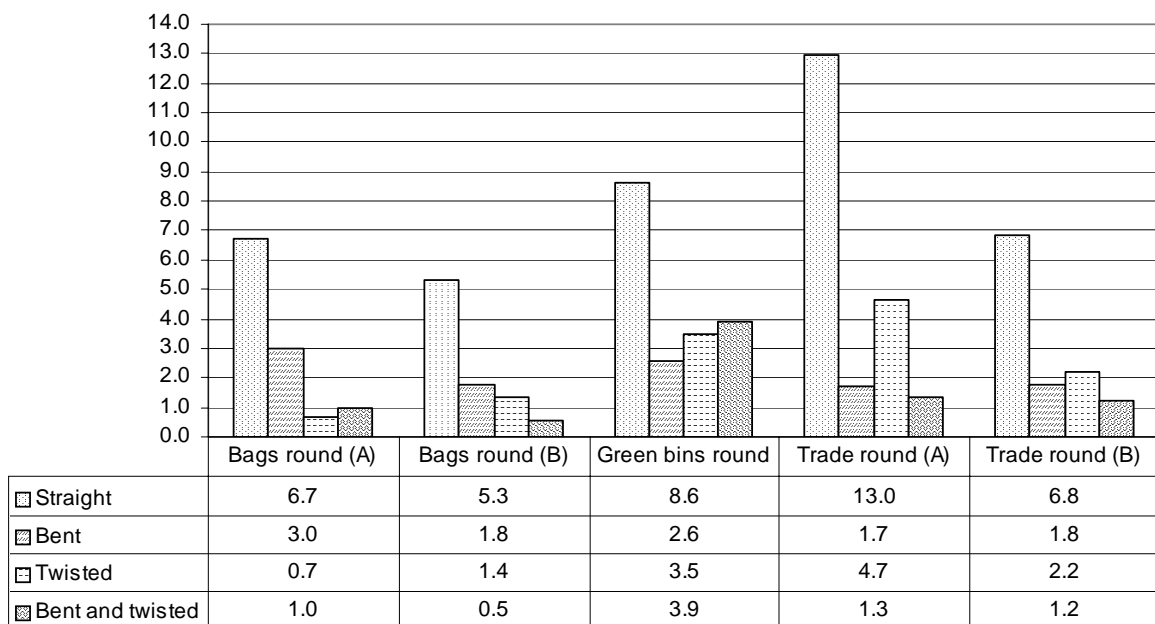


Figure 8. Mean durations (s) of trunk postures

4.1.3. Positions of hands relative to the shoulders

Figure 9 shows how often the coding of hand position relative to the shoulders changed. Between 20 and 40% of the coding changes were due to the hands ceasing to be visible, if, for instance the individual walked out of the field of view of the camera. While the majority of the events show that both hands were below shoulder height, one or both hands went above shoulder height on a significant number of occasions. It is clear from the video that this was almost exclusively associated with throwing bags into the vehicles. That this still occurred on the two rounds dealing with wheelie bins reflects the fact that the trade round was dealing with both bins and sacks, and that the green bins round also had to deal with a level of side waste, usually in plastic bags.

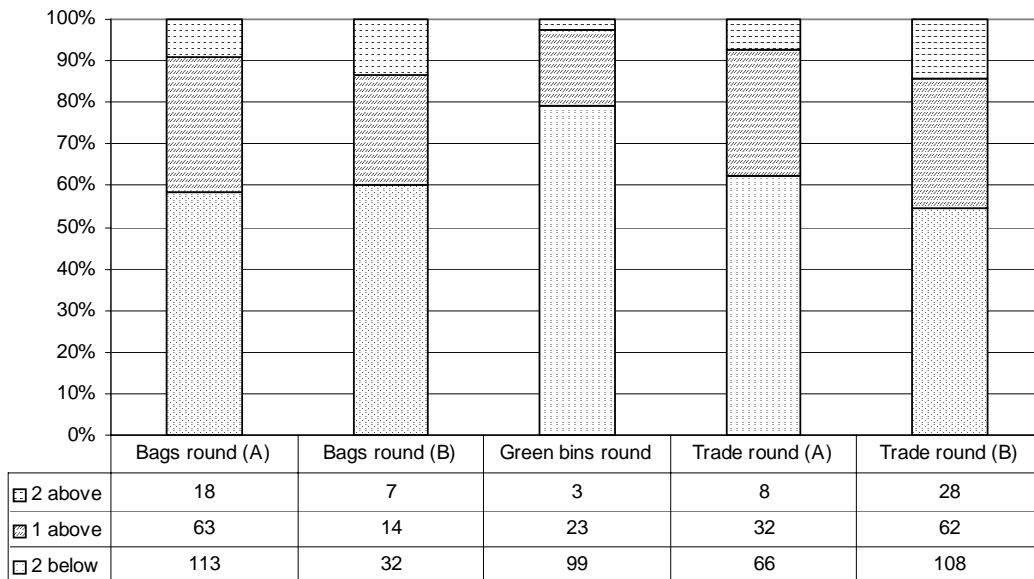


Figure 9. Number of times hand coding changed

Figure 10 shows the percentage of the visible time that one or both hands were above shoulder height. While either or both hands going above the shoulders may have been relatively common events, the total times the hands were in these positions were quite short.

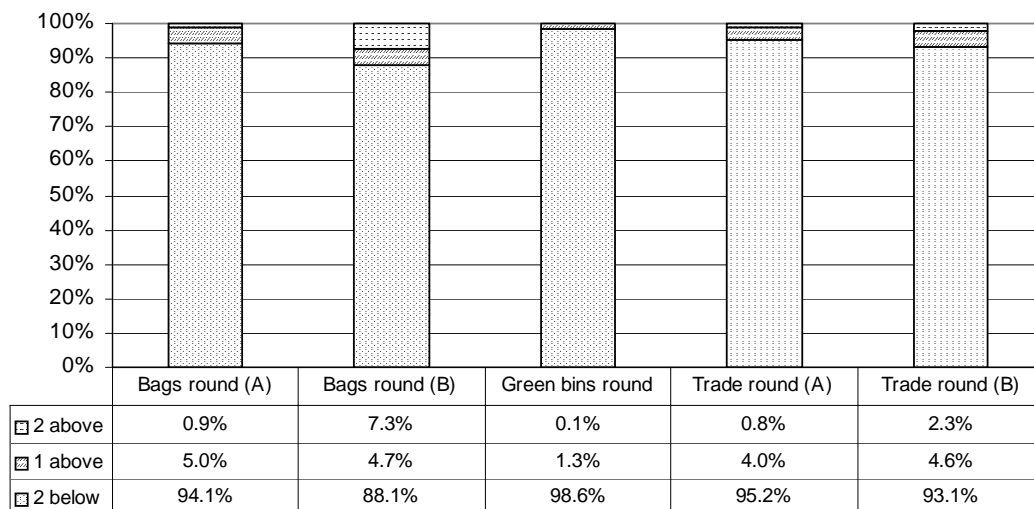


Figure 10. Relative durations of positions of hands relative to shoulders

Figure 11 shows the mean durations of the hand postures. Typically, one or both hands were above the shoulders for less than a second. The normal situation was for the hand to go above the shoulder as the bag was thrown and to be brought down again immediately. This means that the loading on the shoulders in these postures was short duration and dynamic, rather than the worse situation of sustained static loading. The risks would be greater from the throwing than from lifting the hands above shoulder height.

Due to the high rave height, the hands went above shoulder height on numerous occasions while bags were being thrown into the truck. This is a risk factor for musculoskeletal

disorders in the upper limbs, and upper back even though 60% of the bags weighed less than 6 kg and had acquired momentum in the throw while the hands were below shoulder height.

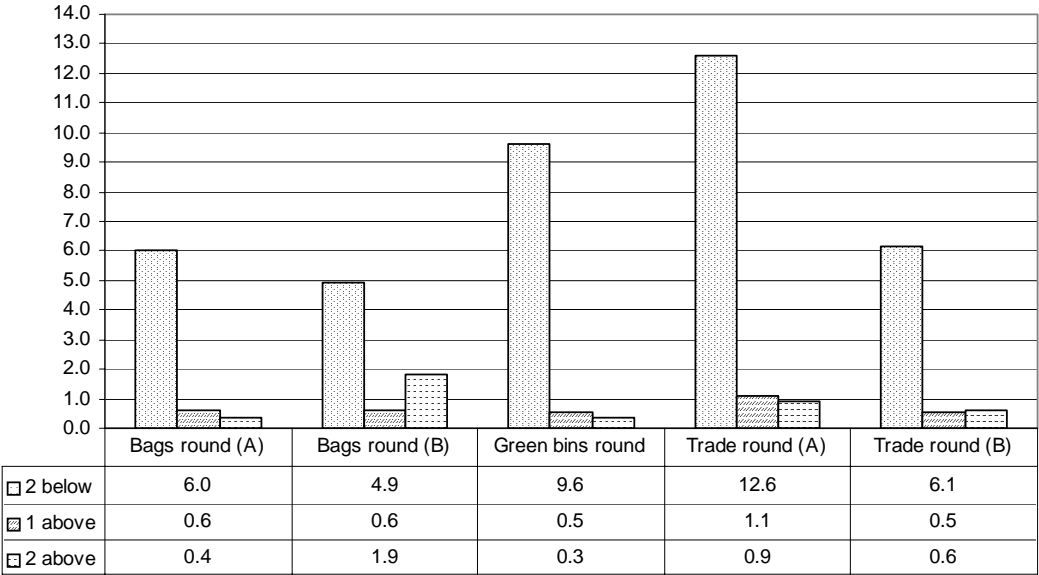


Figure 11. Mean durations (s) of hand positions relative to the shoulder

4.1.4. Leg postures / activities

Figure 12 shows that the leg activities observed were almost exclusively standing or walking. This was partly due to the difficulty of identifying the other possible actions. Ambiguous postures, such as shifting from one foot to the other, were coded as either walking or standing.

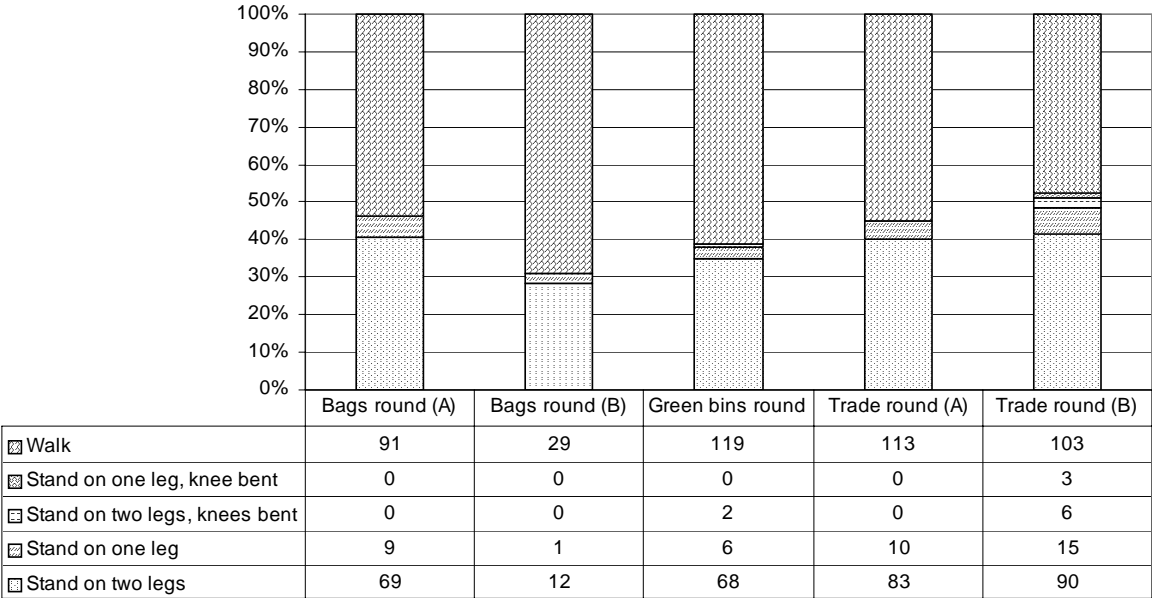


Figure 12. Occurrences of changes of leg actions

Figure 13 shows that large percentages (60-90%) of the observed time were spent walking. This is not surprising since the workers have to walk to collect the refuse and then bring it to the truck. Overall, very few leg postures, other than walking and standing on two legs, were

adopted. Again this reflects the nature of the task which is a collection one. More time was spent standing still on the bins rounds than on the bags round. This reflects the way that the loaders stand and wait while the lift mechanism operates, which is not necessary when dealing with bags. Some of the standing recorded on the bags round was probably an artefact of the study, since, instead of following their normal practice of having two members go ahead to gather bags into piles, all of the loaders remained with the vehicle. On occasion this led to loaders having to stand holding bags since they could not gain access to the rear of the vehicle to throw them in due to other crew members being in the way.

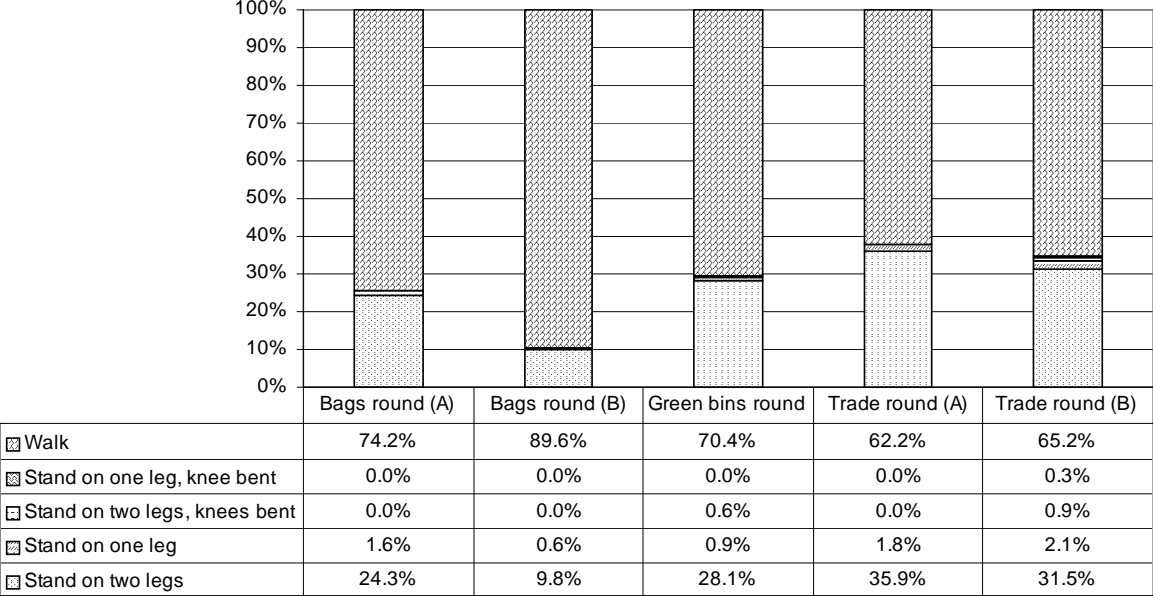


Figure 13. Activity of legs (percentage of visible time)

Figure 14 shows that the mean observed times spent walking ranged between 4.5 and 5.9 seconds. This is a narrow range and the values are almost certainly an artefact of the filming process, since longer periods will have been spent walking to and from the locations where refuse was located, only some of which was captured on camera. The times spent standing were shorter on the bags round than on the bins rounds. This reflects the practice of standing and waiting at the rear of the truck while the lifting gear emptied the bin. The mean periods spent in the other postures, such as standing on one leg or with bent knees, were short but the total time coded for these postures was very short, making it difficult to draw conclusions from them.

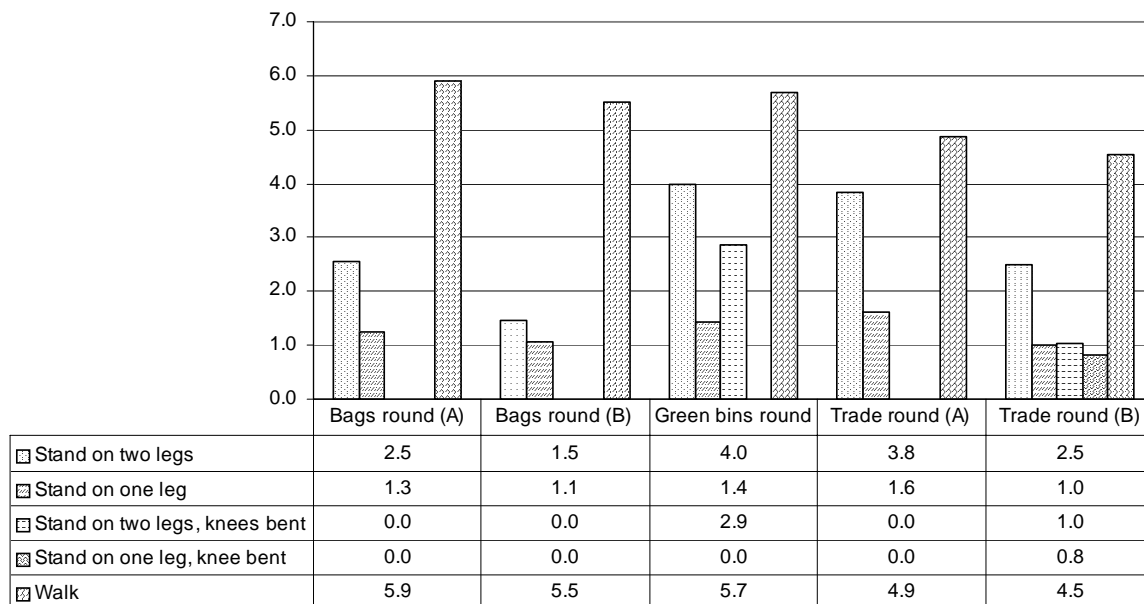


Figure 14. Mean durations (s) of leg activities

4.1.5. Assignment of postures to OWAS Action Categories

Table 25 shows the Action Categories assigned to the percentages of time in Figures 7, 10 and 13 using the boundaries in Table 23. All but two fell into AC 1. The amount of combined bending and twisting of the trunk fell into AC 2 for the green bins round because the percentage was 6.8% as opposed to the boundary of 5%. Some of this may be due to the tendency of workers to pull bins with one hand behind them. Because the difference from the threshold is very small, at only 1.8%, even if the filming and coding could be shown to be error free, the uncertainties of the boundaries of the OWAS Action Categories mean that it would be difficult to justify intervention to attempt to reduce this value.

Table 25. OWAS Action Categories assigned to postures

	Bags round (A)	Bags round (B)	Green bins round	Trade round (A)	Trade round (B)
Bent and twisted trunk	AC 1	AC 1	AC 2	AC 1	AC 1
Twisted trunk	AC 1	AC 1	AC 1	AC 1	AC 1
Bent trunk	AC 1	AC 1	AC 1	AC 1	AC 1
Straight trunk	AC 1	AC 1	AC 1	AC 1	AC 1
2 hands above shoulder height	AC 1	AC 1	AC 1	AC 1	AC 1
1 hand above shoulder height	AC 1	AC 1	AC 1	AC 1	AC 1
2 hands below shoulder height	AC 1	AC 1	AC 1	AC 1	AC 1
Walking	AC 1	AC 2	AC 1	AC 1	AC 1
Standing on one leg, knee bent	AC 1	AC 1	AC 1	AC 1	AC 1
Standing on two legs, knees bent	AC 1	AC 1	AC 1	AC 1	AC 1
Standing on one leg	AC 1	AC 1	AC 1	AC 1	AC 1
Standing on two legs	AC 1	AC 1	AC 1	AC 1	AC 1

The amount of walking, at 90%, on the second film segment of the bags round also fell in to AC 2 since it exceeded 80%. However, since the total length of this film was under two

minutes and because the much longer first segment had a value of 74%, and because of the limitations of the filming and coding discussed above, it is reasonable to ignore this.

4.2. Results of analysis of handling operations

4.2.1. Types of handling operations carried out

Figure 15 shows the different forms of handling occurring in the different rounds as the numbers of changes of action recorded. Between 15 and 40% of changes of action involved the subject having no load in the hands. In the bags round pushing and pulling virtually never occurred. By contrast, in the bins rounds, significant numbers of pushing and pulling events were recorded. Pulling of bins was more commonly observed than pushing them.

Unsurprisingly, large numbers of lifts, carries and throws occurred in the bags round. Smaller numbers occurred on the trade round, which was a mixture of bins and sacks. Because of the presence of side waste on the green bins round some bag handling was required so a certain number of these events also occurred then.

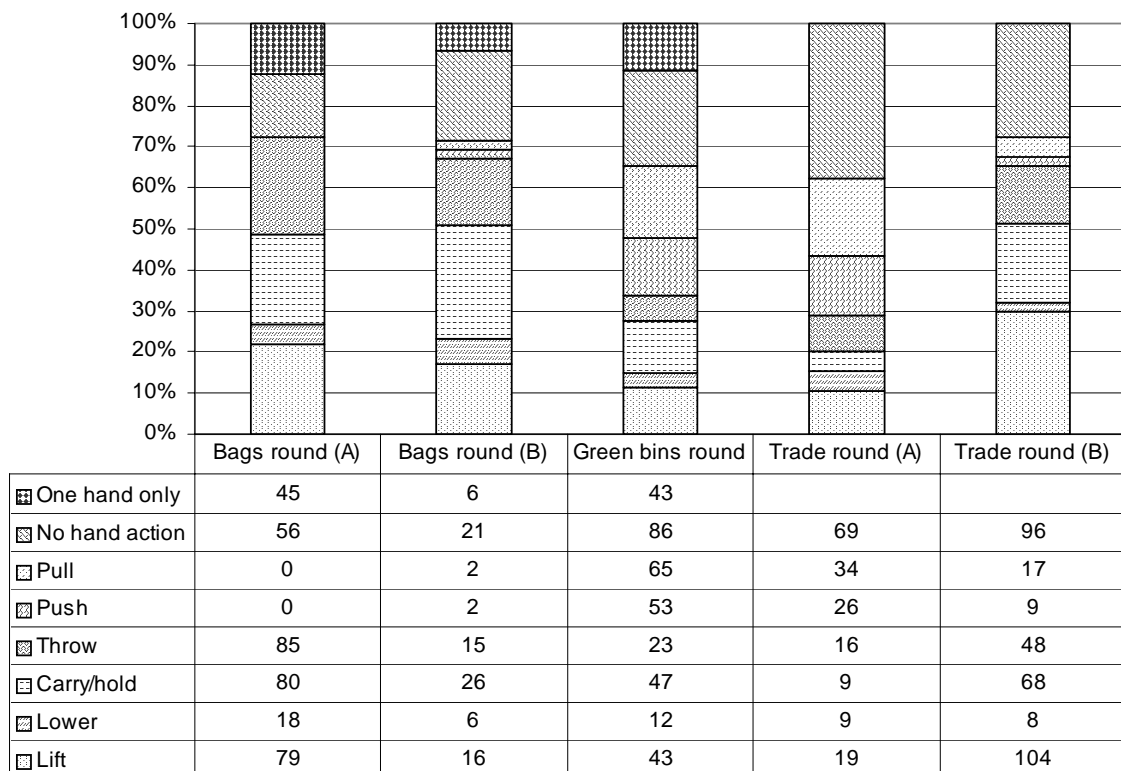


Figure 15. Occurrences of different manual handling operations

With regard to the time spent in each of the activities (Figure 16), the workers had no load in their hands for between 45 and 62% of the visible time, and therefore were not carrying out manual handling operations. The amount of time spent carrying or holding ranged widely, from 15% to 43% for the bags round; 10% for the green bins round and from 3% to 21% for the trade round. No time was spent pulling on the bags round and under 1% pushing. On the green bins round 13% of the time was spent in pushing, and almost twice, 23% spent pulling. For the trade round almost equal times were spent in pushing and pulling (18% and 23% / 6%

and 9%). These differences no doubt reflect the different methods of handling Eurobins compared to smaller ones, particularly the two-man nature of the operation.

For the trade round throws were treated as instantaneous events having no duration. The coding was then changed for the other rounds and throws were treated as states lasting a measurable time. Therefore, the time that was coded as throwing in the later coding of the bags and green bins rounds was coded as lifting for the trade round. The estimates varied considerably between the two film segments with 2% lifting and throwing and 3% carrying and holding for the first, and 13% and 21% for the second. These values are distorted by the fact that the second film segment included a lengthy part where the refuse collectors had to deal with a considerable amount of refuse dumped on the pavement by a carpet shop. Much of this material was pieces of carpet or long cardboard tubes that could not be put into sacks or 1100 litre Eurobins and therefore had to be handled individually and thrown into the crusher.

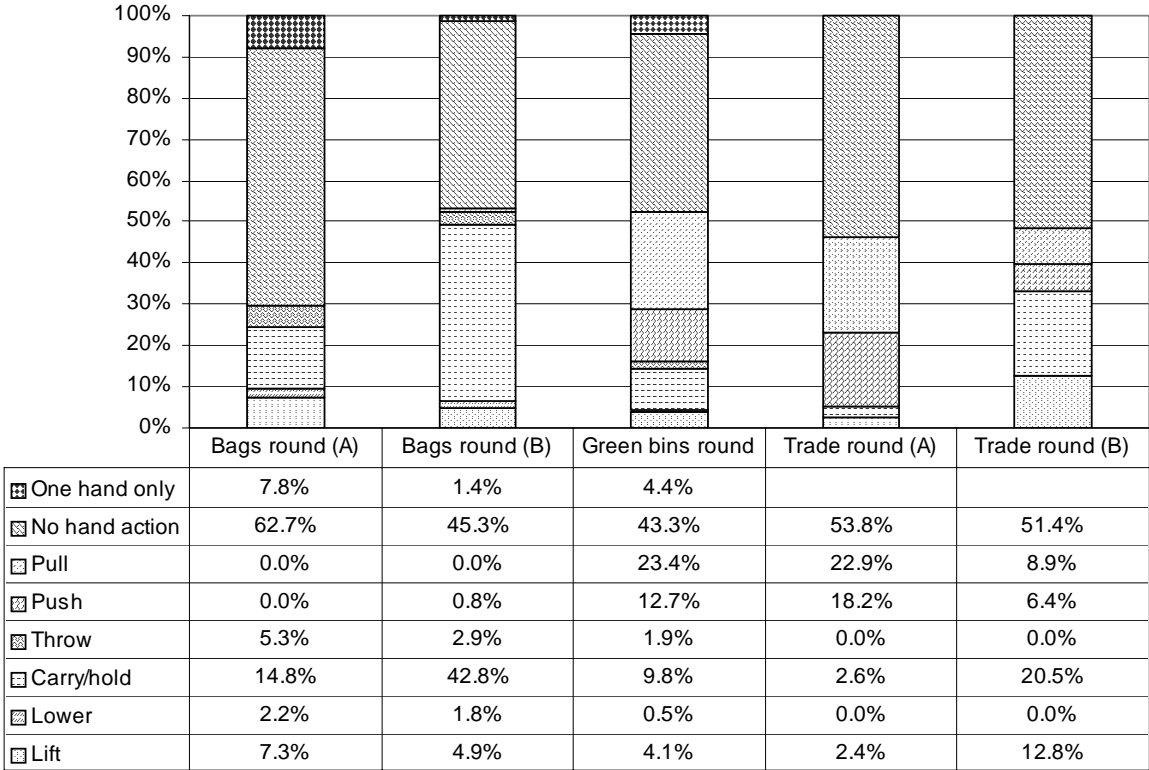


Figure 16. Duration of different manual handling operations (percentage of visible time)

Figure 17 shows how the mean time spent in each form of handling varied. Substantial periods (between 3.8 and 8.1 seconds) were spent with no load in the hands. These will have included periods when the workers were walking from the truck or standing waiting for a bin to be emptied. Lengthy periods of the trade round were spent pushing and pulling, with mean times from 4 to 6 seconds. The mean times for the green bins round were shorter at 2.3 and 3.5 seconds. This suggests that there may be differences in the distances and times that different size bins are pulled and pushed for. The larger 360 and 1100 litre bins are more difficult to manoeuvre than the 240 litre bins and were not handled on the green bins round.

Also, because they are used by commercial premises, they may be stored in locations that are more difficult to access than bins used by domestic premises.

Lifting and lowering actions all had mean durations of 1.1 seconds or less. Often they were carried out in preparation for other longer duration actions, such as holding and carrying. The throwing actions were not timed on the trade round, but had mean times ranging from 0.35 seconds on the bags round to 0.8 seconds on the green bins round. This time was measured from the point at which the hand was seen to start accelerating the load to the instant at which the bag was released. Mean carrying / holding times were between 1.3 and 2.9 seconds. These will have been affected by a number of factors such as the distance that bags were carried, whether bags had been collected together into piles before the arrival of the truck, and how close to the pile of bags the driver brought the truck.

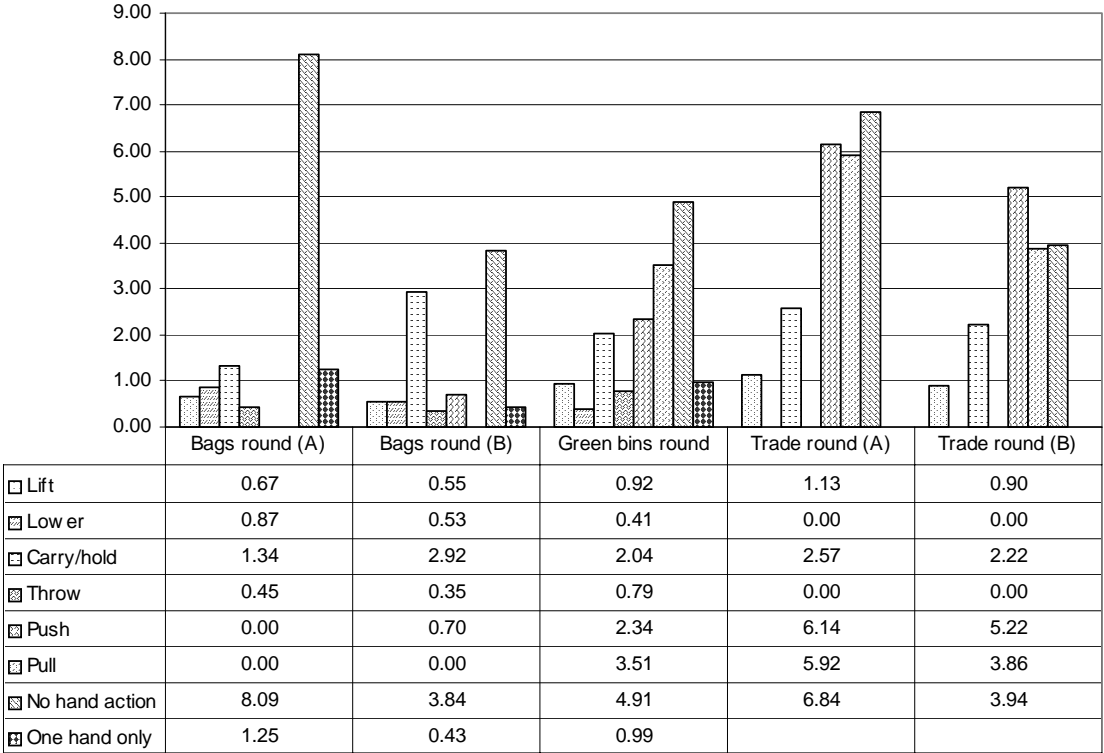


Figure 17. Mean durations (s) of different manual handling operations

4.2.2. Type of object being handled

Figure 18 shows the numbers of times that the different types of refuse container were handled. The coding was carried out separately for each hand and therefore this graph does not show the relationship between what the left hand was doing and what the right hand was doing, except when both hands were handling the same object. Between 20% and 60% of the actions observed involved the handling of a single object (usually a refuse bag) in one or both hands. The highest percentage was on the second film segment from the trade round, much of which involved handling of side waste on the pavement near a carpet shop.

On the first film segment for the bags round, two bags were handled on 100 occasions, which accounted for over 25% of the handling actions. On only a few occasions were more than two bags handled. The seven occurrences of handling four bags in the second segment appear to

have been a very rare occurrence, probably involving small bags, in what was a very short piece of film. No pushing or pulling occurred in the first film, and there were only a couple of occurrences in the second. In all three film segments involving bin handling more actions involving filled bins were observed than ones involving empty bins. On a few occasions on the bags round and green bins round bin lids were handled while bags were removed from the bins to avoid handling bins in awkward locations such as up and down long flights of steps. The bins that were handled in the second film segment from the bags round were round 110 litre bins which were emptied into the back of the truck.

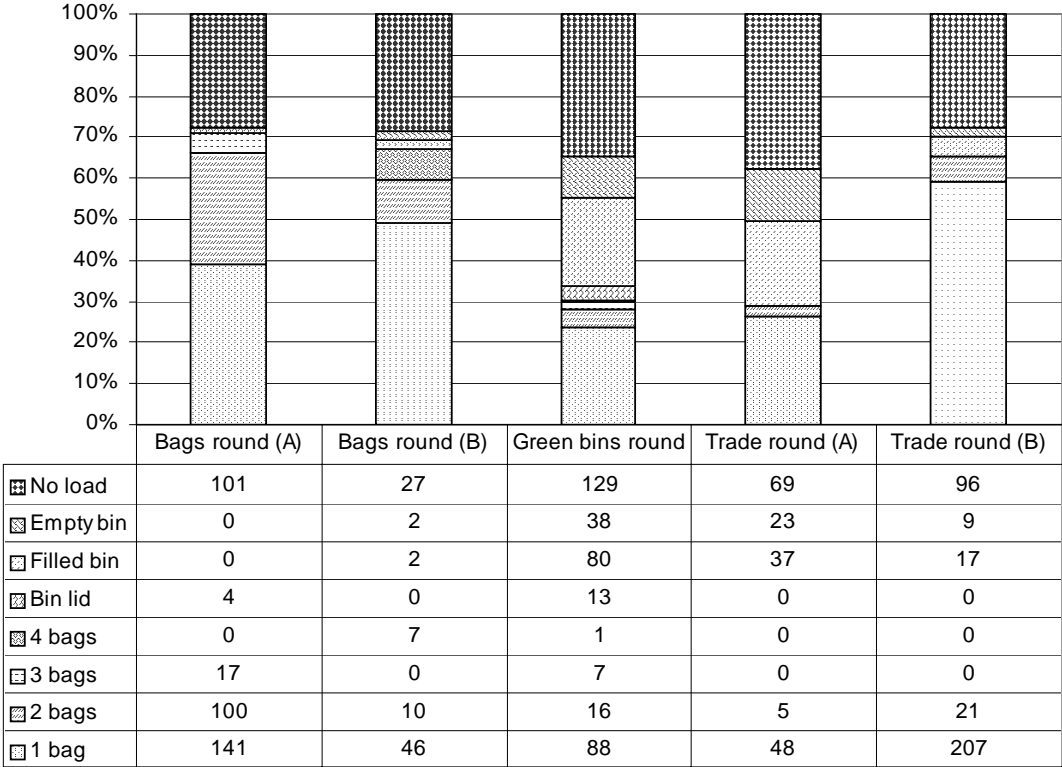


Figure 18. Frequency of handling of different objects

Figure 19 shows the relative times spent handling different objects. The refuse collectors had no load in their hands for between 50% and 70% of the time observed on the bags round. For the bins rounds, approximately 50% of the time was spent with the hands unloaded. For the longer film segment of the bags round, 16% of the time was spent handling one bag per hand, 10% handling two bags, and under 2% handling three bags. Of the 29.5% of the observed time spent handling, nearly 90% was spent with one or two bags per hand.

Sixteen per cent of the observed time for the green bins round was spent handling waste not in bins and 36% was spent handling bins so over 50% of the observed time was spent handling. Despite the round being only supposed to deal with recyclable material placed in easily identifiable wheelie bins there was still a significant amount of handling of bags and other side waste. For the first film segment of the trade round, only 5% of the observed time was spent handling bags, even though the round is described as a mixture of bins and trades sacks, but 41% was spent handling bins. The second segment included the clearing of a large amount of refuse dumped on the pavement near a carpet shop that will have contributed to the 33% of time spent handling ‘bags’.

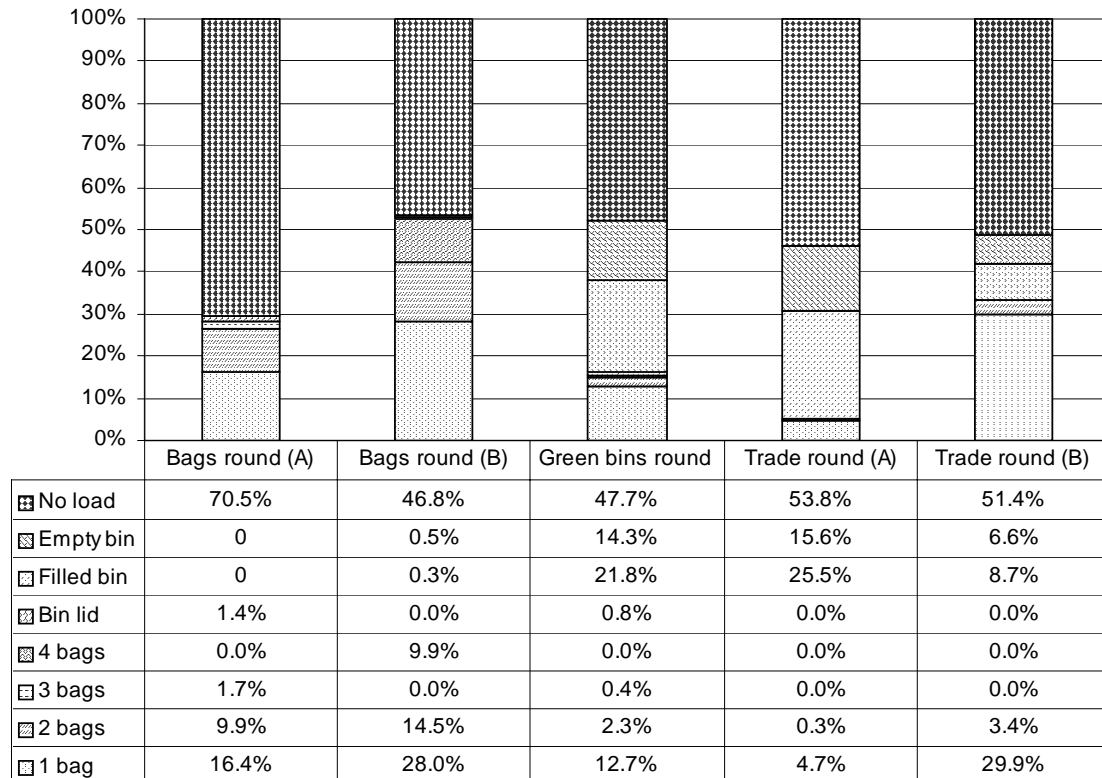


Figure 19. Relative time spent handling different objects

Figure 20 shows the mean durations of handling observed for the different objects. For the first film segment of the bags round, the mean time for bag handling was below 1 second.

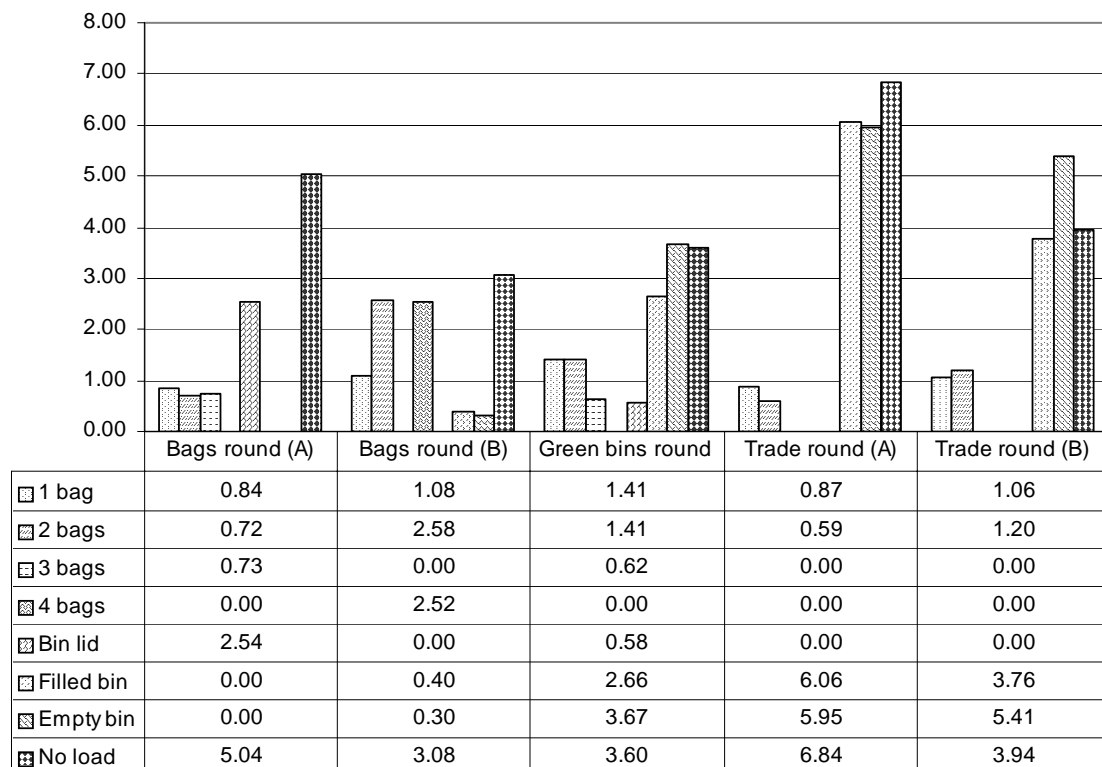


Figure 20. Mean durations (s) of handling different objects

This short duration of bag handling reflects the practice of crew members having gone ahead to gather bags into piles. The instances of bag handling on the bins round were also of short mean duration, with a maximum of 1.4 seconds. The periods without any load in the hands were of relatively long duration, ranging from 3.1 seconds to 6.9 seconds on the different films. Of similar lengths were the times spent handling empty and full bins. This suggests that the longer times spent handling full bins than handling empty ones (Figure 19) are probably artefacts of the filming tending to concentrate on full bins being brought to the truck rather than empty ones being taken away.

4.2.3. Use of the hands in handling refuse

Figure 21 shows how the number of occasions on which objects were being handled by the left hand, by the right hand, or by both hands together varied. Because of the differences in coding methods used to deal with the trade round, where different bin sizes were coded, and the other rounds, where bin handling was coded but bin size was not coded, the values for hands on the trade round in Figures 21 to 23 relate only to handling of bags.

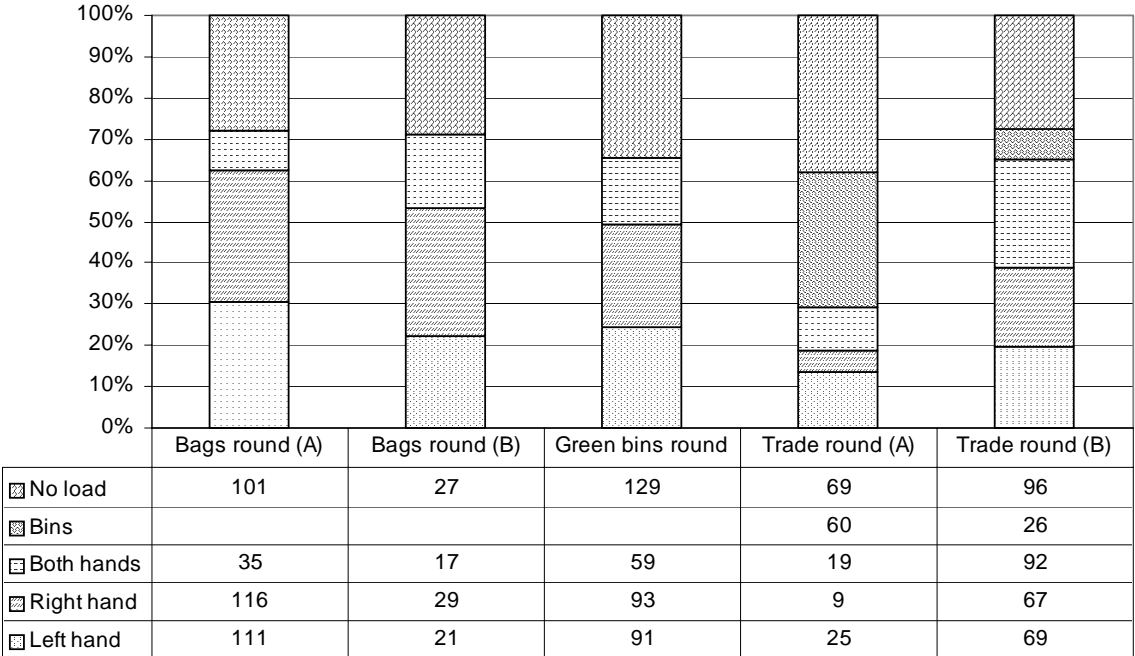


Figure 21. Frequency of use of the hands in handling refuse

For the bags round it was relatively unusual for both hands to be handling the same load, but the two hands were used separately at almost exactly the same frequency. This reflects the tendency of workers to reduce the number of trips they had to make by transporting as much as possible by carrying bags in both hands. It implies that loading on the body was largely symmetrical because of this practice, rather than the more stressful asymmetrical loading that would have been produced if one-handed carrying had been employed.

For the green bins round, relatively more two-handed handling occurred. This will be due to the inclusion of two-handed pushing of wheelie bins in the values rather than a change to two-handed handling of black bags. However, a commonly observed tendency was for the individual to pull one bin and push another at the same time or to carry a bag in one hand and

to pull or push a bin with the other (Figure 43). For the trade round there was a greater tendency for two-handed handling of ‘bags’ to occur. The actual trade sacks being collected were observably bigger than normal black bags (see Figures 28 and 55) but no data were collected on their weights.

Figure 22 shows the relative total times each hand was in use separately or both hands were in use. The percentages should be treated with caution as they do not adequately distinguish periods when only one hand was in use from periods when both hands were in use handling different objects. Despite this, single-handed handling of objects, often with each hand being used for different objects, was more common than two-handed handling of a single object. There were also variations in which hand was used more, which suggests, as with the number of actions, that the total load was relatively evenly distributed across the hands in all rounds.

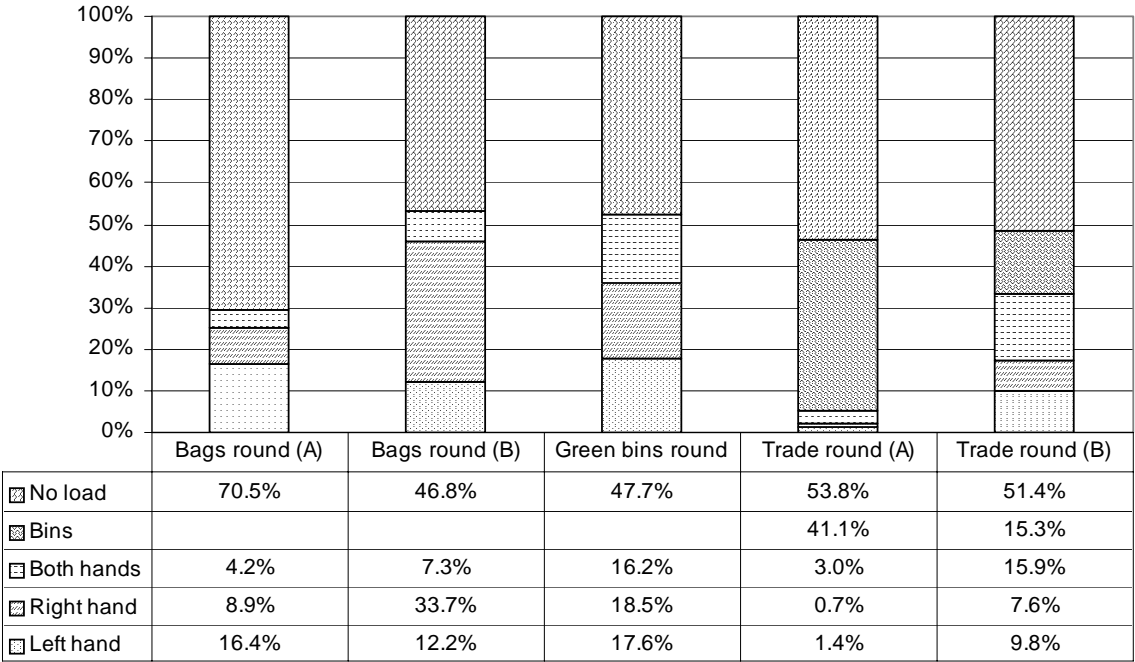


Figure 22. Relative times spent using the hands

Figure 23 shows how the mean durations of hand use varied across the different film segments. Apart from the very short second segment of the bags round, the differences within a round are all less than 1 second. The longest durations are in the green bins round and probably reflect the influence of pulling and pushing bins for periods of several seconds.

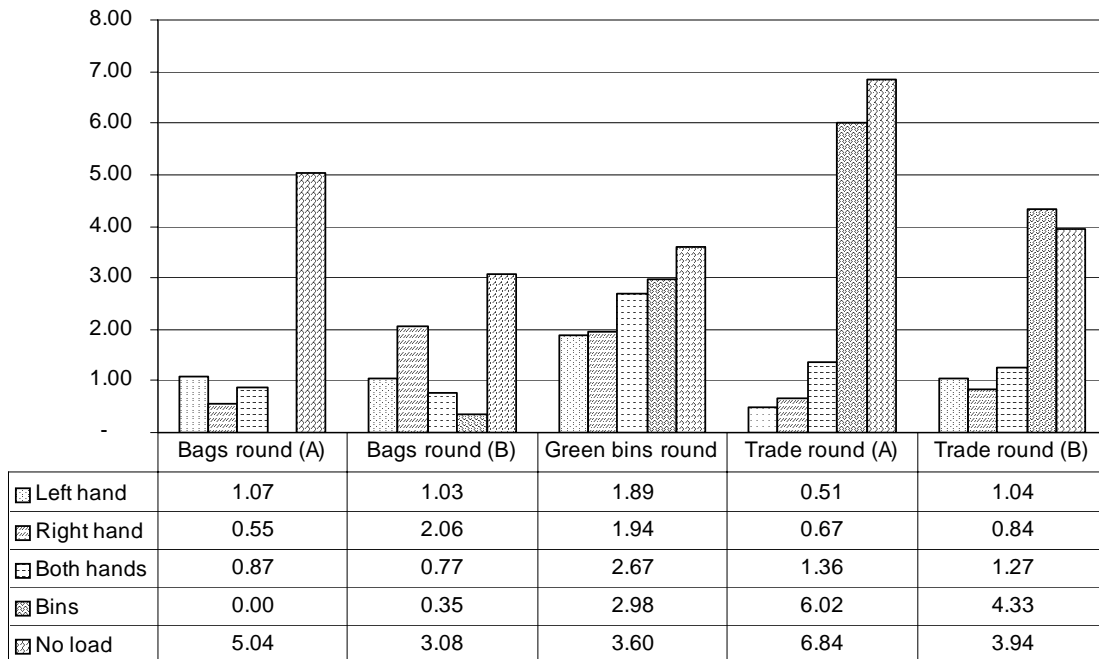


Figure 23. Mean durations (s) of hand use

4.2.4. Sizes of object handled on the trade round

The three sizes (240, 360 and 1100 litre) of bin on the trade round were coded separately but on the other rounds no distinction was made since almost all were 240 litres. Figure 24 shows how the frequencies of handling varied for the different size bins and of 'bags' (the 'bags' classification included a large amount of side waste that was too large to be put into bags, such as carpet offcuts and long cardboard tubes). The Eurobins were handled more frequently than the two smaller sizes, which were found equally often.

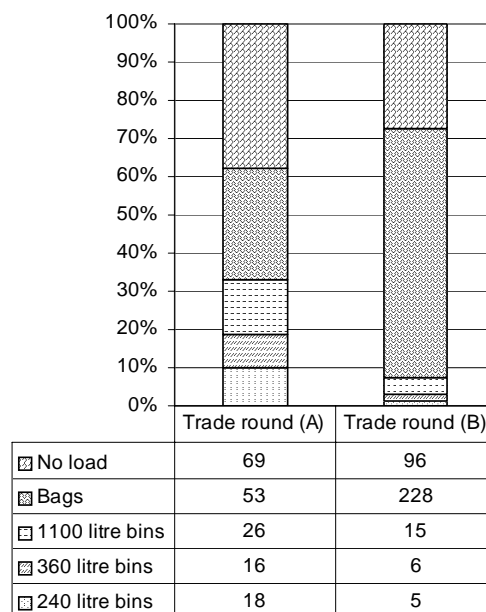


Figure 24. Frequency of handling of different sizes bins

Figure 25 shows that 22% of the first film segment was spent handling 1100 litre bins. This was more than the total time spent handling the two smaller sizes which were roughly equally represented. The same pattern occurred in the other film segment even though far more time was spent handling bags and side waste. While the mix of sizes encountered depends on the premises visited, and therefore on the day of the week, this suggests that the tendency was for businesses to have Eurobins rather than the smaller bins.

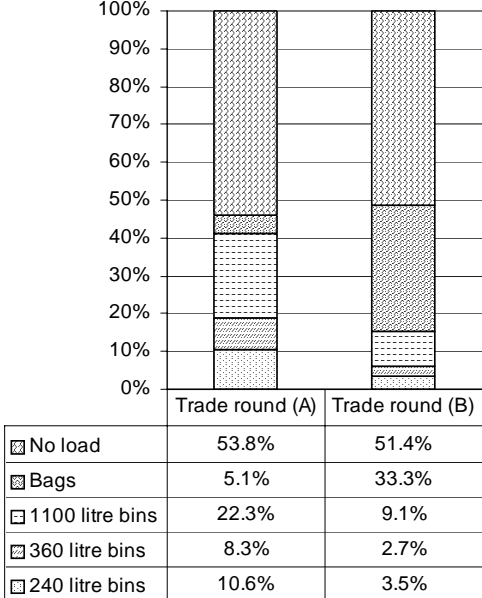


Figure 25. Relative time spent handling different size bins

Figure 26 shows mean durations of handling of the different bins. Except for a longer duration for the Eurobins on the first film segment, there is no clear pattern. Handling times of bins are all significantly longer than for bags, reflecting the need to push and pull bins over longer distances than the bags had to be carried.

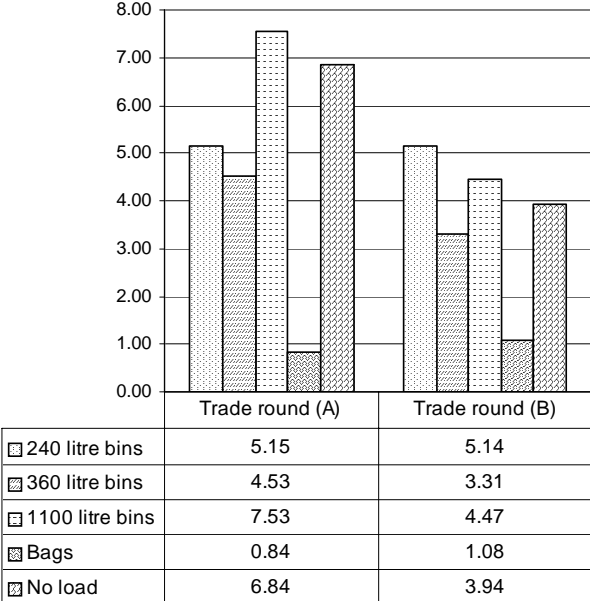


Figure 26. Mean durations (s) spent handling different size bins

4.3. Photographic records

4.3.1. Bags rounds

Picking up bags and throwing them into the back of the refuse truck formed the major part of two of the rounds studied. There were also small numbers of smaller (110 litre) round plastic or metal dustbins and some loose, un-bagged, refuse such as boxes, planks of wood, and TV aerials or rubbish in small carrier bags rather than in full-size black sacks.

Figure 27 shows typical activities of carrying and throwing bags. The refuse collector is carrying two bags in each hand since this reduces the time that a collection round takes. The number of bags taken will depend on the number found since a refuse collector will carry an additional bag rather than make another trip. It will also depend on the actual weights of the bags found since a worker will be able to carry more light bags.



Figure 27. Black bags being carried and thrown into lorry

The video analysis of the first film segment for the bags round showed that the collectors made 6.6 lifts, 6.6 carries and 7.1 throws per minute. Of these throws, 55% were of single bags; the remainder were of two or more bags. Again, weight will have determined the throwing method used. Often collectors were observed to throw the bags in one hand and then the ones in the other, as in Figure 27. When a heavy bag that was too heavy to throw one-handed was encountered, then a two-handed lift and throw would be employed. These handling rates are almost double those recorded by Kemper *et al.* (1990), but the mean weights lifted were lower (9 kg compared to Kemper's 13.4 kg). The 9 kg figure is an overall average for the round, calculated from the mean bag weight and the percentage of two bag and single bag throws.

In addition to the lifting elements of the task, Figure 27 also shows that the throwing also led in some cases to twisting of the back. This is an additional manual handling risk factor.



Figure 28. Black bags ready for collection

At various points on the bags rounds there were large piles of bags for collection (Figure 28). In certain cases these had been arranged by members of the collection team going ahead. In other cases they had been placed in piles by the public. This method reduced the amount of time spent walking collecting and carrying bags. It also split the handling of bags between the workers so that the ones ahead of the truck did the lifting and carrying to the kerbside while the ones behind the truck did the lifting and throwing into the truck. This meant that the most strenuous tasks of carrying and throwing are split between different individuals. It also increases the rate of loading bags into the truck, but decreases the number and duration of stops the truck makes. The net effect is to increase the overall rate of collection, which is desirable from the workers' perspective since they operate on a 'job and finish' basis.



Figure 29. Black bags being loaded into lorry

Figure 29 shows a typical bag carrying posture. The bags are held away from the body in order to reduce contact with the legs. This serves two purposes: it makes walking easier and reduces the risks of injuries from ‘sharps’ (sharp objects). However, holding bags away from the body means that the weight of the bags is taken solely through the arms and shoulders. By contrast, in other occupations, carrying objects, such as boxes, would often be done by holding the object with two hands against the front of the body, thereby transmitting the weight directly to the trunk, increasing the control over the load and reducing the load on the arms and shoulders.

Figures 30 and 31 show the stooping postures that were common during bag rounds. It is clear from the video that the collectors often lifted bags from the ground at large horizontal distances from their feet. It is likely therefore that the initial part of the lift actually involved pulling the loads towards them as they straightened up and that the loads handled in this way were the light ones. Stooping is often preferred by workers to squat or semi-squat lifts because it requires less energy expenditure since only the trunk is being moved, not the whole body.



Figure 30. Black bags / refuse being lifted from the pavement



Figure 31. Black bags being lifted from the pavement

Figures 32 to 34 show plastic bins being lifted and emptied into the refuse truck. Weighing three full plastic bins gave a mean weight of 16.2 kg. These bins have to be lifted over the rave bar at the back of the truck which is at approximately shoulder height of the individual shown. Therefore, he has to lift parts of the bin to above head height. Clearly taller individuals would be more able to lift to these heights than the relatively short individual shown.

The manual handling task is made more complex by the need to change grip repeatedly during the emptying of such a bin. While there are handles at the top of such bins which can be used for lifting from the ground or carrying, emptying the bin, as shown, requires the grasping of the rim and of the base and, possibly, both sides of the base. Also, factors such as the slipperiness of the bin due to rain or other contaminants will affect the ease of handling.



Figure 32. Plastic dustbin being emptied into back of lorry



Figure 33. Bins being carried to and emptied into lorry



Figure 34. Bin being tipped into truck

While the majority of refuse is not intrinsically harmful or is adequately wrapped, on occasion refuse collectors come across hazardous items such as pieces of broken glass, as shown in Figure 35, or discarded syringes. It is normal for them to wear Kevlar trousers to protect against contact injuries from sharp objects in plastic bags. They also all had gloves that they wore at intervals throughout the rounds. The glass shown in Figure 35 was clearly visible and the individuals handling it took sufficient care that they did not suffer injury despite not wearing gloves. It is common for local authorities to ask householders to wrap sharp objects in multiple layers of newspaper to prevent injuries to their workers. However, if this location had been visited before daybreak or if the glass had been inadequately wrapped or just put into a plastic bag so that it was not easily identifiable then the risk of injury from handling it would have been significantly higher.



Figure 35. Handling of pieces of broken glass

One feature of the city where the study was carried out is that in some areas refuse is collected from alleys running along the length of a road behind the houses. These may only have entrances at the ends of the street meaning that all refuse bags have to be carried to either end before they can be loaded into the truck. As shown in Figure 36, the surfaces may vary from good tarmac surfaces along which it is easy to walk and wheelie bins could be pushed or pulled, to overgrown muddy tracks where it will be necessary to fight through undergrowth such as brambles.



Figure 36. Back alleys with hard and unmade surfaces

4.3.2. Green bin round

Figure 37 shows the labels placed on grey and green bins in an area where recycling collections are carried out. These encourage householders to separate their waste into recyclable and non-recyclable. However, the expectation is that glass bottles and jars will be recycled via bottle banks in supermarket car parks. When recyclable material is collected it is tipped straight from the green bin into a standard refuse lorry with a crusher. No attempt is made by the crew to exclude material that shouldn't be recycled and no attempt is made to separate the waste. Once the lorry is full, it is driven to the waste transfer station and emptied. The material is loaded onto a belt and sorted manually. While this task was not seen during the visit, the sorting must be a physically demanding and hazardous task because of the need to separate different types of recyclable waste from the crushed material while leaving the residue of unrecyclable waste which should not have been collected.

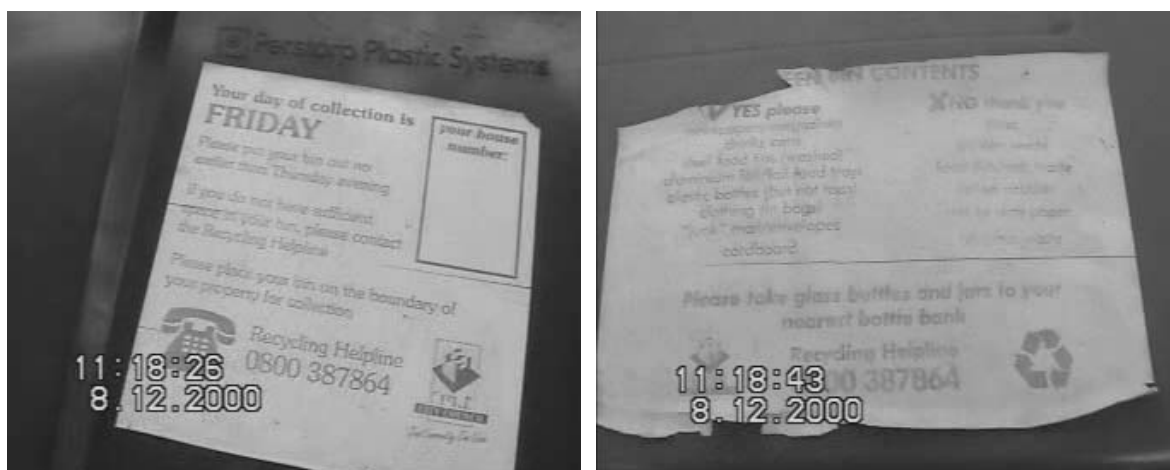


Figure 37. Labels on grey and green bins

Often the bins had to be bumped up and down kerbs (Figure 39), though where dropped or low kerbs (Figure 38) were available they were used.



Figure 38. 240 litre green bins being pushed toward lorry



Figure 39. Handling of bins across kerbs

One of the most significant differences between handling bags and bins is that as soon as the worker has thrown a bag he can turn away from the truck in order to go and fetch the next one, but emptying a bin is more involved. First he has to push the bin onto the bin lift and then has to stand back to avoid being struck by the bin as it is lifted (Figure 40). On this occasion the lift was set to operate when the bin was pushed onto it, whereas on the trade round, the bin would only lift when the controls on the side of the truck were activated. While the lifting mechanism is going through its cycle of lifting the bin, automatically shaking it to ensure the rubbish falls out and then lowering it back to the ground the worker is quietly standing watching it and waiting. Only when the bin is approaching the ground will he reach to grasp the handle so he can pull it away from the truck as the wheels touch the ground. Because of this completely different method, workers handling bins spend longer standing still and are far less likely to raise their hands above shoulder height than workers throwing bags.



Figure 40. 240 litre green bin being pushed onto bin lift

At some locations, numbers of bins had to be retrieved from outbuildings. The positioning of many of these stores behind the buildings that they serve meant that retrieval involved pulling or pushing the bins longer distances than on typical residential streets where the bins are left in front of the houses.

Officially, the green bin round dealt with green 240 litre wheelie bins only (Figures 38-40). In many cases the bins were only partly filled. However, side waste, such as bags or cardboard boxes, was often encountered and had to be loaded into the truck (Figures 41-43). Sometimes this entailed handling both a bin and a bag simultaneously (Figure 43).



Figure 41. Handling of side waste on green bins round



Figure 42. Carrying and throwing of side waste



Figure 43. Combined handling of bins and bags on green bins round

Both hilly and flat areas were covered by this round. There were a number of premises where the bins had to be pulled up, and then back down, flights of stairs (Figures 44-45). While, on this occasion the flight of steps was relatively short, it did create problems with pulling the heavier bins up the steps and with controlling the empty bins being dragged down them which tended to bounce around.

At one location the bins were stored at the top of a large flight of steps with an awkward corner at the bottom. The refuse collector chose (Figure 46) to remove the rubbish from the bin and manually carry it down the steps rather than have the difficulty of manhandling the bin down the steps and then back up them. This was made more difficult by the fact that the rubbish was in small bags, rather than a large refuse sack, meaning that the worker had to pick them out of the bottom of the bin and then carry several small bags down the steps.

There is probably no easy solution to such problems in the hilly parts of an area where recycling rounds occur. Ramps are only possible for relatively small changes of level due to the need to avoid steep slopes that would be particularly hazardous in wet or icy conditions.



Figure 44. Handling of green bins up and down steps



Figure 45. Handling of green bins up and down steps



Figure 46. Removal of waste from a wheelie bin to avoid handling it up and down a flight of steps

4.3.3. Trade round (bins / bags)

The trade round dealt with a wide range of bin and refuse types ranging from bags to 1100 litre Eurobins. As Figure 47 indicates, the refuse collectors acknowledged that best practice was to move the Eurobins in pairs. This is a positive finding and is supported by the literature, which suggests that working in teams like this can reduce spinal loading by as much as 75%. Where possible the Eurobins were pushed / pulled across dropped kerbs or ramps but in situations where this was not possible, full Eurobins had to be dropped down kerbs and the emptied bins pulled back up.



Figure 47. Eurobin being wheeled from store

As can be seen from Figures 48-50, considerable effort can be required to move a full bin. A variety of pulling and pushing postures were adopted depending on the weight of the bin, the precision with which it needed to be directed (most precisely at the point of bringing it to the bin lift), and the slope (if any) of the ground. Postures could be one or two-handed and were typically asymmetrical, with the hand(s) either to one side or behind the trunk. Sometimes both hands were on the same handle on the bin and sometimes on separated handles.

The sequence does not show that, before loading the bin onto the lifting mechanism, excess bags visible in Figure 48 were manually removed from the top and thrown into the truck. This then allowed the top of the bin to be moved to the closed position (Figure 49) before the bin was actually lifted.



Figure 48. Pulling of full 1100 litre bin to truck



Figure 49. Loading and lifting of Eurobin onto truck after removing excess waste and closing lid

The lifting mechanism consisted of two parts which therefore could allow two smaller bins to be lifted independently. Because of the mixture of bin sizes being handled, the mechanisms were set so that they could only operate when the buttons on the control panels on the side of the vehicle were being pressed. A different practice was observed on the green bin round where 240 litre bins were being pushed onto the mechanism, activating a switch, which lifted them automatically. This positioning of the controls means that the operator must stand to the side of the vehicle out of the path of the bin being lifted. The manual control meant that a single operator could empty one of the smaller bins using one side of the mechanism, but both operators were required to work together to empty one of the Eurobins using both sides of the mechanism. This has the advantage that it will lead to the workers not handling these bins as individuals. The actual emptying process involved three stages: lifting the bin, shaking it to make the contents fall out, and lowering it down to the ground. The timings on the video

frames (Figures 49 and 50) show that on this occasion the bin remained in the up position, being shaken to force the waste out of it, for approximately 20 seconds. Occasionally, as shown in Figure 51, the bin became stuck in the up position and the crew had to pull manually on the wheels to free it again. It is not clear why this happened but a number of causes are conceivable. These would include problems with the lifting mechanism, damage to the bin, or a design flaw in the system allowing rubbish to fall into a gap in the mechanism, thereby jamming it. Such a situation is very hazardous since the refuse collectors could sustain overexertion injuries, or worse, if the mechanism suddenly came free. It also has the problem that it slows down the collection process.



Figure 50. Shaking and lowering of 1100 litre bin



Figure 51. Refuse collectors attempting to free a Eurobin stuck on the bin lift in the up position

One of the major problems faced by the refuse collectors during the trade round was manoeuvring bins in constricted spaces such as narrow alleys (Figure 52). The primary problem is there is likely to be an increased twisting of the back in these situations in order to grip the handles of the bins. Because of the awkward postures, there is also likely to be greater use of small muscle groups in the upper limbs to manoeuvre the bins, where larger muscle groups in the back and legs would be used in less restricted spaces. These forces

would need to be applied to the bins to move them into a position from which they can be pushed or pulled along the alleys / through narrow gaps.

Other problems arise with narrow alleys and doorways due to obstructions and poor ground surfaces. The space restrictions may mean that such obstructions cannot be avoided. This may cause overexertion injuries as bins are pulled or pushed over them. The space restrictions will also reduce the ability of other refuse collectors to assist in these situations.



Figure 52. 240 litre trade bins being manoeuvred in alleys

Figure 52 also shows another problem that occurred on the trade round: manoeuvring 240 litre bins up and down steps. In this case a full bin is being pulled down a set of steps, again in an alley. Given that these bins can weigh up to approximately 75 to 80 kg this activity could lead to excessive compressive forces on the lower back.

Contamination of steps is yet another hazard that can be seen in Figure 52. There are black bags and loose refuse on the ground creating slipping and tripping hazards that could have resulted in loss of balance whilst the refuse collector was trying to manoeuvre a bin up or down the steps, especially in wet conditions. This combination of hazards could result in sprain injuries, abrasions, bruising, etc., if a fall were to occur.

Figure 53 shows a case where a refuse collector was removing a 360 litre bin from its store. This is an example of a situation where he could have reduced the precision of manoeuvre needed by opening the second door and giving himself more space. However, this would then

have increased the time spent opening and closing the doors and would therefore have slowed the round down slightly.



Figure 53. Removal of 360 litre bin from refuse store

Occasionally, locations were encountered where the bin was stored at some considerable distance from the point to which the vehicle could be brought. Figure 54 shows a 360 litre bin being returned from the truck up a path leading to a sports field and a building in the distant background. Such problems can only be overcome by proper vehicular access to the site.



Figure 54. 360 litre bin being returned to distant storage location

Figure 55 shows a combination of one worker loading a 360 litre bin onto the bin lift to empty it while the other prepares to throw a trade sack into the crusher.



Figure 55. 360 litre bin and trade sack being loaded into truck

Figures 56 to 61 shows a sequence of (unevenly spaced) video frames of handling of three trade sacks. In the first frame the operative is carrying two sacks in his left hand and one in his right. In the second frame he has dropped the front sack in his left hand and started to throw the other. By the fourth frame (Figure 57), another second later, he has stopped walking towards the lorry, his left hand has gone above shoulder height and he is releasing the bag he is throwing. He is still holding a bag in his right hand. Apart from a slight lean of his trunk visible in the third frame, all the motion has come from his left arm. Within the next second he starts to lift the second sack with his right hand, grasps the bottom of it with his left as he does so, and performs a two-handed twisting throw into the vehicle. At this point his right hand is above shoulder height and his left is approaching it.



Figure 56. Carrying three trade sacks and starting to throw the first



Figure 57. One-handed throw of the first sack into the back of the truck



Figure 58. Two-handed throw of the second sack into the truck

Two seconds later (Figure 59) he is stooping to start a two-handed lift of the third sack. As he brings his trunk upright (Figure 60) he starts a twisting throw, bringing his hands to above shoulder height as he releases the sack (Figure 61). The process of loading three sacks into the truck takes only five seconds from walking up to the vehicle to releasing the third sack.



Figure 59. Two-handed lift of the third sack from the ground



Figure 60. Two-handed lift and twisting throw of the last sack



Figure 61. The point of release of the last sack

4.4. Heart rate data

4.4.1. Bags round

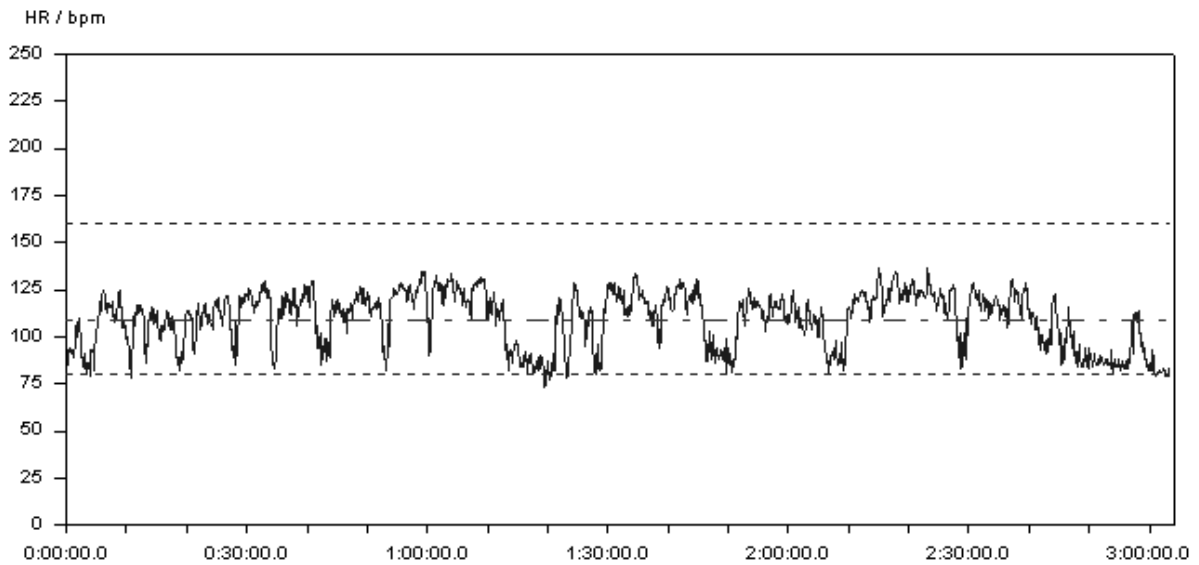


Figure 62. Bags round, Subject A

Overall mean recorded heart rate = 109 bpm. Mean resting heart rate = 88 bpm.
Work Pulse (working pulse - resting pulse) = 21 bpm.
Data were recorded every five seconds for 3 hours and 3 minutes starting at 06:27.

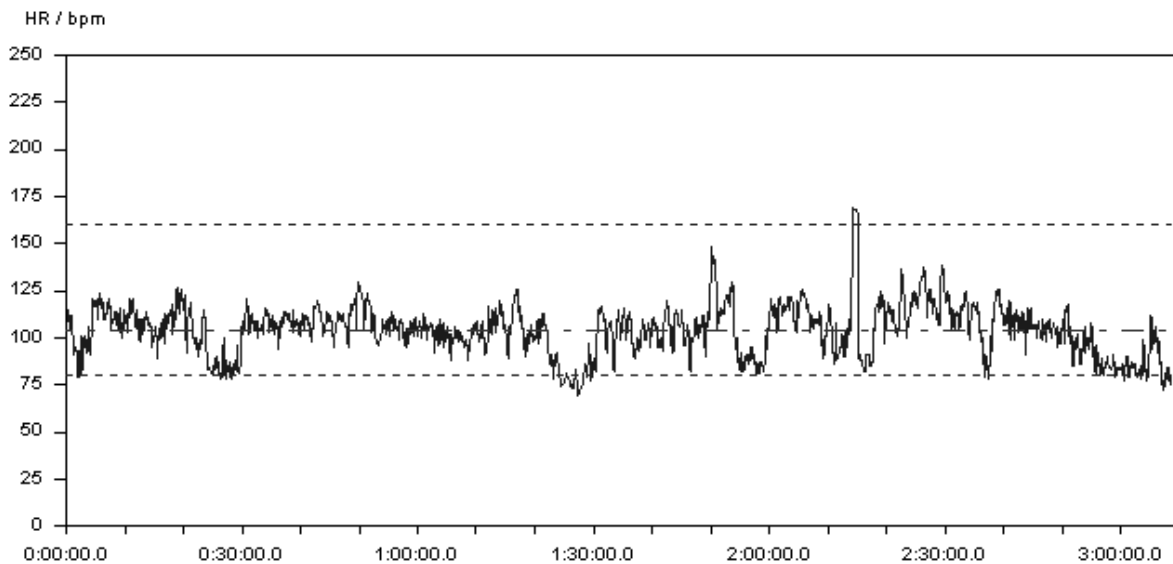


Figure 63. Bags round, Subject B

Overall mean recorded heart rate = 104 bpm. Mean resting heart rate = 84 bpm.
Work Pulse (working pulse - resting pulse) = 20 bpm
Data were recorded every five seconds for 3 hours 3 minutes starting at 06:19.

4.4.2. Green wheelie bins round

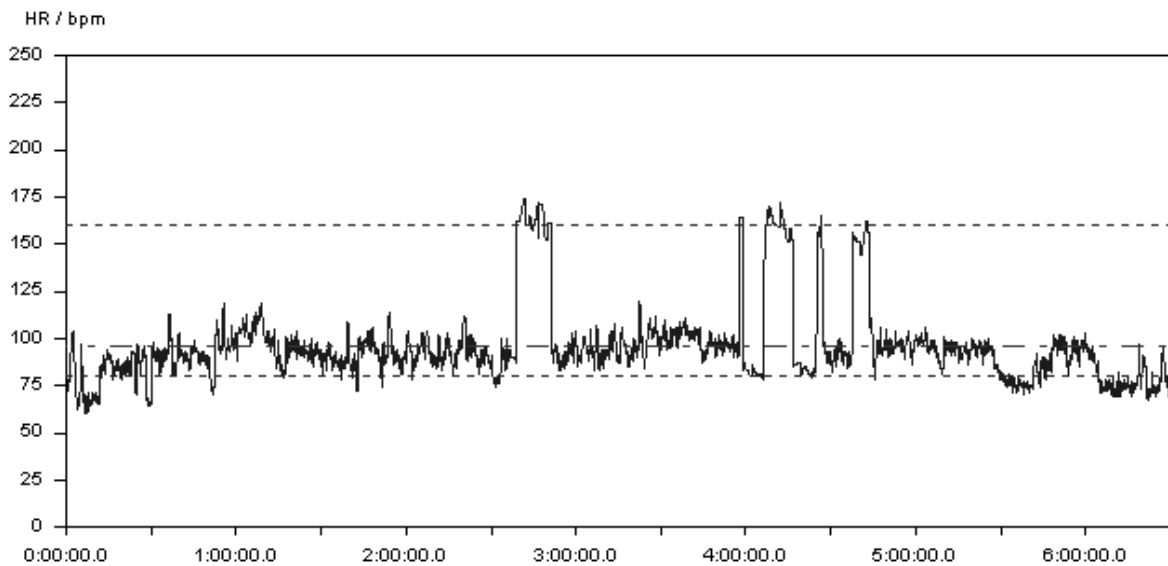


Figure 64. Green wheelie bins

Overall mean recorded heart rate = 96 bpm. Mean resting heart rate = 76 bpm.

Work Pulse (working pulse - resting pulse) = 20 bpm

Data were recorded every five seconds for 6 hours 30 minutes starting at 05:59.

Data were recorded from another subject for every heart beat for 46 minutes starting at 09:23. The heart rate monitor had been handed to the driver at 06:00 with a request to ask a crew member they would pick up part way to wear it. It was explained that the watch was pre-set and a single button press would start recording. The worker changed the recording interval from 5 s to the beat by beat setting and did not start recording until several hours into the round. As a result, the watch memory was full when it was collected at approximately 12:30, having recorded only 46 minutes of data. The graph of the data is not shown since it does not reflect the heart rate over the shift.

4.4.3. Trade round (bins / trade sacks)

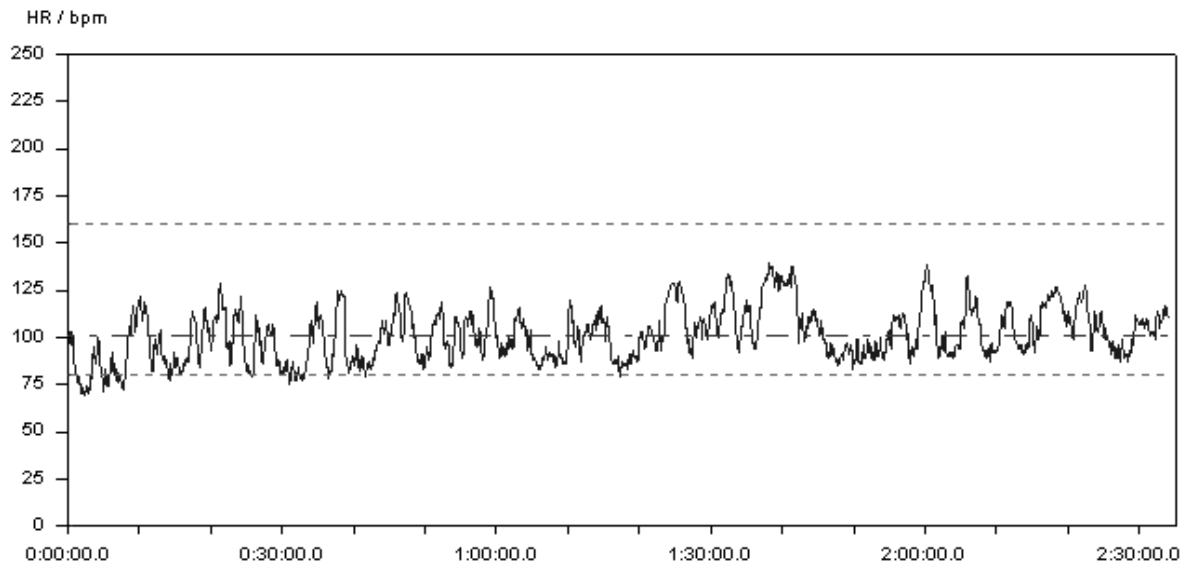


Figure 65. Trade round, Subject A

Overall mean recorded heart rate = 101 bpm. Mean resting heart rate = 87 bpm.
Work Pulse (working pulse - resting pulse) = 14 bpm
Data were recorded every five seconds for 2 hours 35 minutes starting at 14:49.

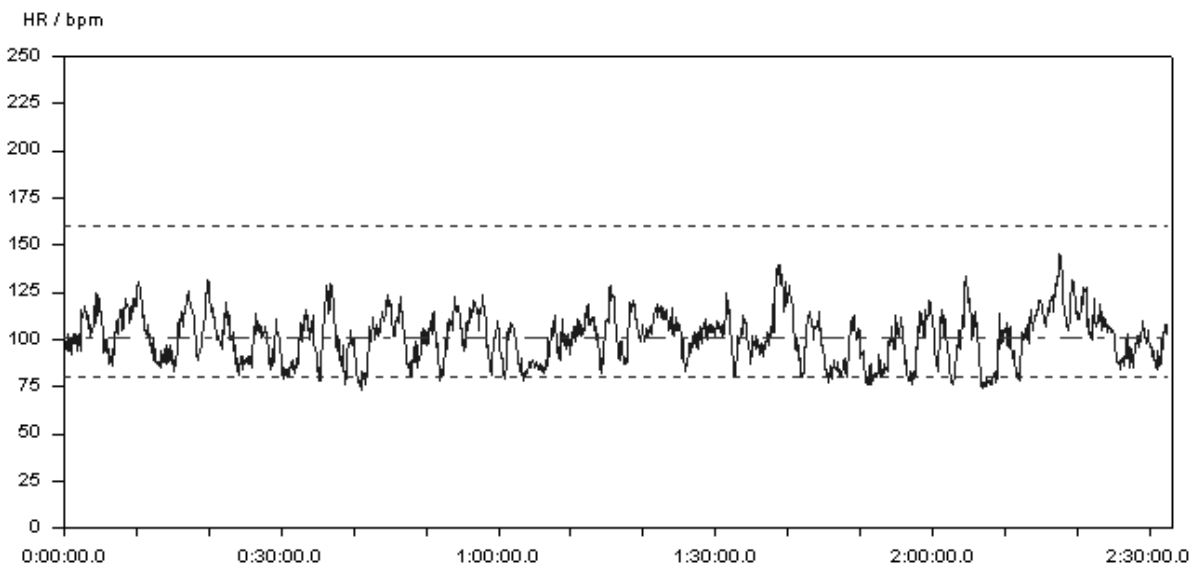


Figure 66. Trade round, Subject B

Overall mean recorded heart rate = 101 bpm. Mean resting heart rate = 82 bpm.
Work Pulse (working pulse - resting pulse) = 19 bpm
Data were recorded every five seconds for 2 hours 32 minutes, starting at 14:50.

4.5. Bag weights

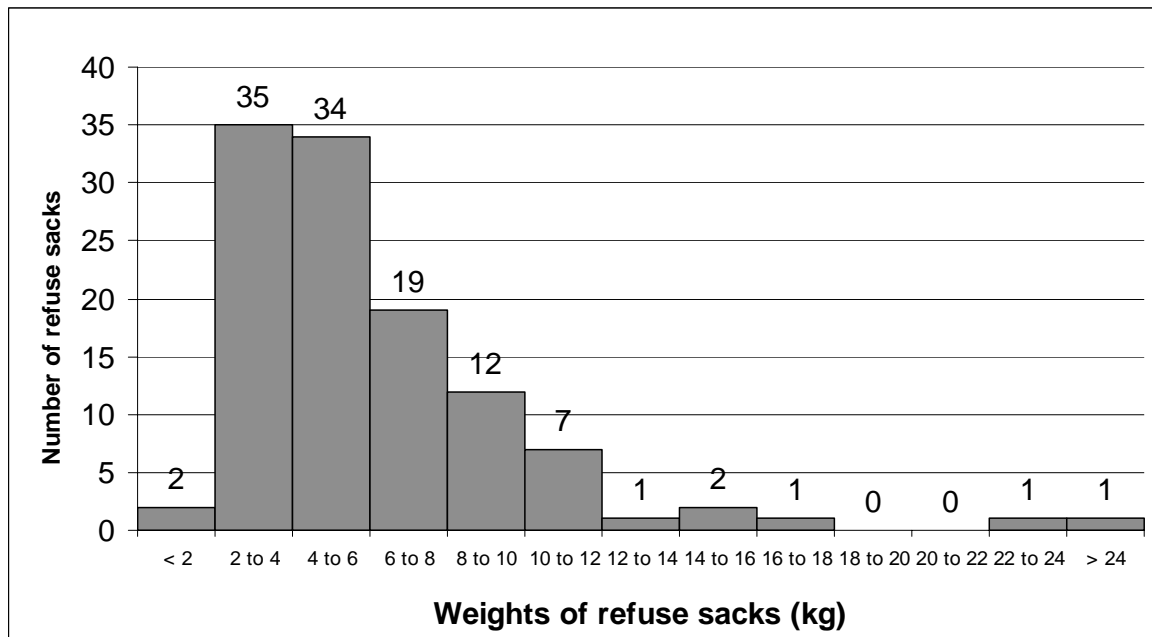


Figure 67. Distribution of weights of bags

Figure 67 shows the distribution of weights of a total of 115 bags. The mean weight was 6.2 kg (standard deviation of 3.9 kg), but the distribution of weights is almost J-shaped, being skewed to the heavy side of the normal distribution, with a few very heavy sacks extending the tail even further. 60% of the sacks weighed between 2 and 6 kg, with almost equal numbers between 2 kg and 4 kg and between 4 kg and 6 kg. 33% were between 6 kg and 12 kg. A ‘modal’, or ‘typical’ weight of a sack could therefore be considered to be 4 kg.

It is worth noting that the visits were made quite close to the Christmas holiday season (7th / 8th December). According to the crews the volume of rubbish had started to rise above the normal and this may have had some effect on the average weights of bags. It is therefore possible that the average weights at this time of year were slightly higher than normal. In other words, where a household might normally have put out two full bags and a half full bag, they might have put out three full bags instead. In the Dutch context, van der Beek *et al.* (1999) commented that “seasonal variation is known to be very large in refuse collecting”.

On the other hand, the weights are slightly lower than those found in previous studies. Frings-Dresen *et al.* (1995a) found a mean bag weight of 7 kg, and Kemper *et al.* (1990) found a mean number of bags and weight lifted per throw to be 1.8 bags and 13.4 kg (a mean weight of 7.4 kg per bag).

Clearly, a determining factor is the capacity of the bag and their strength. Bags were not supplied by the local authority so households may purchase the cheapest ones available, which will tend to be weaker. This will have the effect of tending to limit the weight of rubbish put into each bag, thereby decreasing the mean weight and increasing the number of bags to be collected. However, if a household has particularly heavy items to dispose of, they may deliberately use stronger bags.

5. DISCUSSION

5.1. MSD risk factors

The hazards that refuse collectors are exposed to vary depending on the type of collection round they are working on. The bags rounds present musculoskeletal risks associated with stooping to pick up bags, lifting and throwing bags and occasional lifting of bins to above shoulder height. Also much of the handling was asymmetric, with one-handed lifting and carrying, and trunk twisting and many of the loads themselves were asymmetric and with relatively poor grips. The trade round and the green wheelie bin round present risks associated with pushing and pulling bins up and down kerbs, steps and across thresholds, and exerting forces in awkward postures to manoeuvre bins. While the use of wheelie bins dramatically reduces the scale of manual handling, inevitably some bags are found on these rounds, so the associated risks are not completely removed. It also significantly reduces the risks from hazardous waste since it is enclosed in a solid bin rather than a flimsy plastic bag.

Tables 26 and 27 list the risk factors that need to be considered in a manual handling risk assessment under the 1992 Manual Handling Operations Regulations for wheelie bins and bags, respectively. In an approach based on the checklist of Appendix 1 of L23, the HSE guidance on the 1992 MHOR, (HSE, 1998), these tables indicate whether a risk factor is present, and if so, its frequency, its possible harmful consequences, and an estimate of the ease of eliminating the risk factor. Finally, possible solutions are listed, along with factors affecting the ease of implementing these possible solutions.

5.2. Bag handling

5.2.1. *Weights of bags*

The filter in Appendix 1 of L23 (HSE, 1998) states that, for lifts at approximately knee height, which is typical for lifting and carrying black bags, a detailed risk assessment should be carried out if a male worker has to lift, infrequently, more than 10 kg (load between elbow and arm's length away) or 20 kg (load beyond elbow distance away). However, the lift rate on the bags round was over 6 lifts per minute. The guidance suggests that the filter values should be cut by 50% at this rate, which would give values of 5 and 10 kg per lift.

Most bags were lifted close to the feet so that the mean (6.2 kg) and modal bag weights (4.0 kg) came within this range. However, because a number of the bags exceed this weight range and because, in many cases, more than one bag is lifted at once in each hand, the actual weights handled are likely to be significantly in excess of the filter values. Thus, lifting two 4 kg bags in each hand would give a total load of 16 kg. Where bags have to be lifted, rather than thrown, into the truck, they have to be lifted to head height or above. The guideline value for infrequent lifts to head height are 10 kg and 5 kg for 'near' and 'far' lifts. Reducing these figures by 50% for the effect of frequency gives figures of 5 kg and 2.5 kg. Therefore, it can be concluded that such lifting is hazardous to at least some of the male working population.

Table 26. Risk assessment for handling of bags

Factors listed in Schedule 1 of the MHOR 1992	No	Yes How frequently?			Possible harmful consequences of the risk?	Ease of eliminating the risk? (1= very easy; 5= very hard)	Possible solutions?	Factors affecting the suggested solution(s)?
		Rare	Occasional	Regular				
The tasks - do they involve:								
• holding loads away from the trunk?				X	Low back pain	5	Wheelie bins	Terrain, public antipathy
• twisting?				X	Low back pain	5	Wheelie bins	"
• stooping?				X	Low back pain	5	Wheelie bins	"
• reaching upwards?				X	WRULD	3	Wheelie bins	"
• large vertical movement?				X	WRULD	3	Wheelie bins	"
• long carrying distances?				X	Fatigue	3	Wheelie bins	"
• strenuous pushing or pulling?	X				Slips and trips, MSDs	3	Wheelie bins	"
• unpredictable movement of loads?		X			Fatigue	3	Wheelie bins	"
• repetitive handling?				X				
• insufficient rest or recovery?	X							
• a work rate imposed by a process?				X	Fatigue	3	Wheelie bins	"
The loads - are they:								
• heavy?			X		MSDs	4	Educate public; weaker bags	Weaker bags more likely to split
• bulky/unwieldy?				X	MSDs	5	Smaller bags	More lifts
• difficult to grasp?			X		Loss of grip, MSDs	4		
• unstable/unpredictable?				X	Loss of control	4	Educate public	
• intrinsically harmful (e.g., sharp/hot)?			X		Contact injuries; infection	3	Gloves & Kevlar trousers	Acceptability to users
The working environment - are there:								
• constraints on posture?		X			MSDs	4	New truck design	Cost, life span of vehicle
• poor floors?				X	Slips & trips	4	Repave poor areas	Cost
• variations in levels?				X	Slips, trips and falls	5		
• hot/cold/humid conditions?				X	Fatigue	5	Only collect in fine weather	Not practical
• strong air movements?				X	Harder to handle large loads	5		
• poor lighting conditions?				X	Various	5	Only collect in daylight	Not practical in winter
Individual capability - does the job:	No	Minor	Med	High				
• require unusual strength / height?			X		Fatigue	4	Fitness testing	Healthy worker effect
• hazard those with a health problem?					Infection / MSDs	5	Health screening / inoculations	
• hazard those who are pregnant?	X							Exclusively male workforce
• call for special information/training?			X		Sharps / trapping accidents	2	Safe system of work and sharps handling policy	
Other factors: Is movement or posture hindered by clothing or personal protective equipment?		Yes			Injuries due to non-use of PPE	4	Check suitability of PPE	Gloves worn only some of time

Table 27. Risk assessment for handling wheelie bins

Factors listed in Schedule 1 of the MHOR 1992	No	Yes How frequently?			Possible harmful consequences of the risk?	Ease of eliminating the risk? (1 = very easy; 5 = very hard)	Possible solutions?	Factors affecting the suggested solution(s)?
		Rare	Occasional	Regular				
The tasks - do they involve:								
<ul style="list-style-type: none"> • holding loads away [forward] from the trunk? • twisting? • stooping? • reaching upwards? • large vertical movement? • long carrying distances? • strenuous pushing or pulling? 	X			X	Low back pain	4	Better storage locations	Terrain, housing stock
<ul style="list-style-type: none"> • unpredictable movement of loads? • repetitive handling? • insufficient rest or recovery? • a work rate imposed by a process? 	X			X	Fatigue	5	Bigger wheels, smaller bins	More bins or more side waste to deal with
				X	Slips and trips, MSDs	5	Leave overfull bins	PR problems with public
				X	Fatigue	5	Use larger bins	Greater load per bin
				X	Fatigue	5	Enforce breaks; clock in/out	Unlikely to be accepted by workforce
The loads - are they:								
<ul style="list-style-type: none"> • heavy? 				X	MSDs	4	Use smaller bins	More bins or more side waste
<ul style="list-style-type: none"> • bulky/unwieldy? • difficult to grasp? • unstable/unpredictable? • intrinsically harmful (e.g., sharp/hot)? 	X			X	MSDs	4	"	
	X			X	Loss of control	5	Leave overfull bins	PR problems with public
The working environment - are there:								
<ul style="list-style-type: none"> • constraints on posture? • poor floors? • variations in levels? • hot/cold/humid conditions? • strong air movements? • poor lighting conditions? 	X		X		Slips and trips	45	Repave streets / alleys	
				X	Slips, trips and falls	5	Install dropped kerbs	
				X	Fatigue	5	Only collect in good weather	
				X	Fatigue	5	"	
				X	Various	5	Only collect in daylight	
Individual capability - does the job:	No	Minor	Med	High				
<ul style="list-style-type: none"> • require unusual capability? • hazard those with a health problem? 		X			Fatigue	4	Fitness testing	Healthy worker effect
		X			Infection (Hepatitis. HIV) / MSDs	5	Health screening / Inoculations	
<ul style="list-style-type: none"> • hazard those who are pregnant? • call for special information/training? 	X				Sharps injuries / trapping accidents	2	Safe system of work and sharps handling policy	Exclusively male workforce
		X						
Other factors:		Yes						
Is movement or posture hindered by clothing or personal protective equipment?		Yes			Injuries due to non-use of PPE	4	Check suitability of PPE	Gloves worn only some of time

Mital *et al.* (1997) list maximum recommended weights for a range of manual handling tasks. For lifting from the ground to a height of 1.83 m (i.e., to approximately head height) they give values of 9 kg and 6 kg as acceptable to 90% of the male working population at rates of four and eight lifts per minute respectively. These figures relate to two-handed lifts of a 34 cm deep box with handles. While a one-handed lift and throw of a bag is different to a two-handed lift of a box, the mean measured bag weight of 6.2 kg and the modal value of 4 kg suggest that the actual lifting of the bags at 6 - 7 lifts per minute to the back of the truck is within the capability of almost all male workers. Less than 10% of sacks weighted more than 12 kg. Mital *et al.* (1997) also quote a figure of 26 kg as acceptable to 50% of the male population at a frequency of one lift per minute. This suggests that the heaviest bags encountered can be loaded into the refuse lorry by only half of the male population and therefore constitute a significant hazard. When confronted by such bags, weaker refuse collectors may find it necessary to obtain help from other crew members.

The nature of the refuse collection task means that the operators do not know how heavy an item will be until they have begun to lift it, though visual clues, such as the fullness of the bag, may give them some indication. The bag weight data indicates that less than one in twenty bags weighed over 14 kg, but occasionally bags may weigh as much as 22 or 24 kg. Because the normal practice is to grasp the bag at the top where it is tied the refuse collector can get a feel for the weight of the bag by pulling at it and if need be release it again if it is too heavy.

5.2.2. Handling of round dustbins

The traditional dustbins were found only occasionally (such as towards the end of bags round) and had a mean weight of approximately 16 kg. These bins had to be lifted over shoulder height often with one or both arms extended in order to tip their contents into the refuse truck. Even held close to the trunk this weight exceeds the 10 kg filter figure for infrequent lifts. The combination of awkward lifting and reaching postures, lack of suitable handholds and potentially high weights of the bins and their contents make this a potentially high risk task for injury to the lower back and possibly the shoulders.

5.2.3. Stooping while picking up bags

It was clear from the video that the normal practice is for workers to stoop while picking up bags (Figures 29-31). This is well known to be the preferred method of handling, especially when carrying out frequent or repetitive handling. The long-standing advocacy by manual handling trainers, particularly those of the kinetic handling school, of bending the knees not the back, has had little impact upon real-world manual handling. This is partly due to stooping being more energy efficient than squatting and partly due to it only being practical for two-handed lifting of compact loads. While involving the strong leg muscles is desirable, especially when handling heavy loads, such a handling technique is only appropriate for a small proportion of the loads observed on the bags round. Also, training has been shown not to be an effective method of reducing manual handling injuries. Generally, because the bags are large, relatively light (60% under 6 kg) and several can be grasped and lifted with one hand, it is not surprising that the refuse collectors stoop to pick them up, as this is almost certainly the most efficient method of handling them. Thus to handle two 4 kg bags in each

hand gives a total load of 16 kg. To handle three 2 kg bags in each hand would give a total load of only 12 kg.

5.2.4. Trunk twisting and raising the arms above shoulder height

When throwing bags into the refuse truck, the refuse collectors were often seen to twist their trunks (Figure 68). However, such actions were always dynamic and of short duration occupying 2.1% and 5.4% of the time coded from the two film segments of the bags round. Such upright twisting is of lower risk than when combined with bending or stooping or when exerting large forces in a static posture or when carrying it out for a much greater proportion of the time.

The video shows the refuse collectors raising their arms over shoulder height when throwing bags into the truck (Figure 68). The postural analysis showed that they spent between 6 and 12% of the coded time with one or both hands above the shoulders. However, because angular momentum can be imparted to the bags throughout the swing phase, the forces being exerted by the time the arms have reached this height will be less than would be required to lift the bag to the same height. If there is not enough space to swing the bags cleanly (i.e., to start exerting the swinging force when the bags are being held at knuckle height) then the full weight would have to be lifted over the lip at the back of the truck.

Further exploration of the issue highlighted by de Looze *et al.* (1995), of the high forces associated with acceleration of bags just before release in a throw, would be helpful since the throwing of bags was carried out with the trunk upright. It is surprising that they obtained larger truncal compressive estimates for this aspect than for the lifting of bags from the ground which is likely to have been carried out with the trunk in at least partial flexion.

5.2.5. Throw in height of the truck ('rave height')

Figure 68 shows the rave bar at the back of the truck at two heights. On the left, it is above the top of the control panel on the side of the truck. On the right, it is a similar distance below the top of the panel. Lifting the bar increases the height that bags must be thrown over and bins lifted over which increases the risk to the refuse collectors. They expressed a strong preference for having it at the lower height but said they had been told not to lower it by management for safety reasons. They were unable to say what these reasons were.

At a later date the local authority provided measurements of the rave rail heights in the up and down positions on a selection of their vehicles. The heights ranged from 1.245 m to 1.345 m in the down position and from 1.42 m to 1.575 m in the up position. On the type of vehicle followed on the bags round the down height was 1.345 m and the up height was 1.5 m, giving a difference of 0.155 m.

The preference of the workers for a marginally lower throw-in height was strong. de Looze *et al.* (1995) were unable to demonstrate a difference in spinal loading due to two significantly different throw in heights (0.68 and 1.25 m) but did demonstrate a difference in shoulder loading. This finding is somewhat surprising and begs the question of where the additional shoulder moment was going to at the higher height if it was not being transmitted to the back. Analysis of the throwing technique, particularly the height and direction of release for the two

heights might clarify this issue. It may, therefore, reflect a limitation of their model. In such circumstances, the subjective preferences of the workers performing a job are often a much better guide to the stressfulness of a manual handling task than even a sophisticated biomechanical model, which, by its very nature, is a significant simplification of a complex mechanical system.

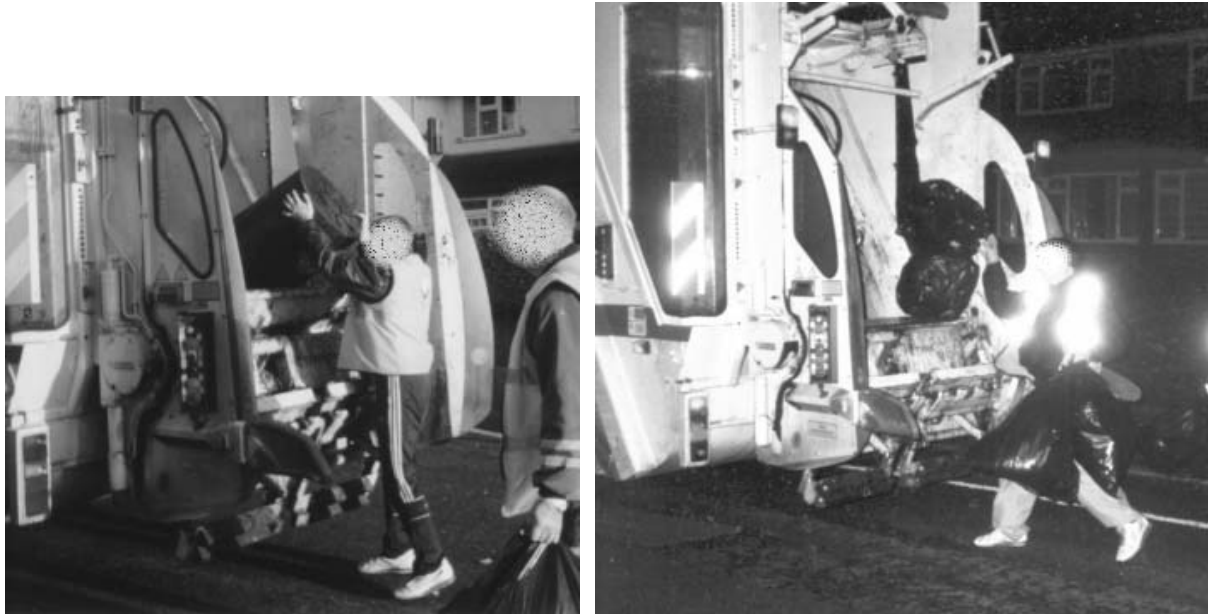


Figure 68. Variations in height of the lip at the back of the refuse truck

5.3. Handling of wheelie bins

5.3.1. *Manoeuvring bins in restricted spaces*

Manoeuvring bins through doorways and in alleys, around obstructions and up and down flights of stairs can lead to refuse collectors twisting their backs and adopting awkward postures whilst exerting forces to move the bins. The problems can be overcome to some extent by looking for ways to make moving the bins less awkward by opening both doors if double doors are available on refuse stores and moving obstructions (e.g., bags or smaller bins) before attempting to move the bins. Team work has a part to play by ensuring that individuals help each other when attempting to move a bin in a particularly awkward location.

5.3.2. *Kerbs, steps and obstructions*

Lifting or pulling bins up kerbs was observed on a number of occasions during the trade round and green wheelie bin rounds. The literature review found that spinal compression reached peaks when pulling bins up kerbs and were particularly high for the larger 1100 litre bins.

These bins were only moved across kerbs, not up and down steps. Typically, Eurobins would be pulled or pushed down kerbs when full and pulled back up the kerbs after they had been emptied. The action of pulling up kerbs, although infrequent, has been found to cause spinal compression forces above the NIOSH Action Limit. The refuse collectors that we observed were aware that they often needed to use two people to move them. They also made efforts to

manoeuvre the bins across dropped kerbs and to avoid pulling them up kerbs, thus reducing spinal compression as much as possible.

The 360 litre wheelie bins were typically handled by one refuse collector as shown in Figures 53 to 55. There is not a great deal in the literature about the weight of these, but a mean filled weight of 65 to 70 kg was estimated from the weight of a 110 litre bin of approximately 22 kg found by Jäger *et al.* (1984). They also found that the horizontal push-pull forces for bins were approximately 13% of bin weight. This provides an estimated push-pull force of around 9 kg (90 N) for the 360 litre bins. It is not clear whether this estimation is a starting / stopping force or a sustained push / pull load. If it is the starting / stopping force, it falls well within the 25 kg (250 N) guideline figure in L23 (HSE, 1998). If it is, the sustained movement force also falls within the 10 kg (100 N) guideline. However, as Figures 53 to 55 also show, these bins are frequently handled down slopes and steps. Supporting these bins down steps or kerbs or even pulling them across obstacles could increase the push-pull force considerably and should therefore be avoided wherever reasonably practicable. If it is found that a large number of these bins have to be moved down steps or across kerbs, then steps should be taken to reduce this number as far as possible.

5.4. PPE and additional health risks

Sharp objects such as glass and metal in refuse, particularly in bags, can lead to cuts to the legs and arms and hands. For this reason, the refuse collectors are issued with high visibility trousers and jackets made with Kevlar to provide protection against this hazard. While protective trousers and jackets will be put on before the start of the shift, they need to be comfortable enough to be worn in all weather conditions that are encountered during the shift. Thus, particularly in summer, if the workers are becoming overheated due to exertion they are likely to remove outer layers of clothing, particularly jackets. This will then remove the sharps protection and expose them to the hazard. Therefore, the workers should be encouraged to remove layers of clothing below the jackets and then to put the jackets back on. Also, such protective ensembles should be designed to remove perspiration from the skin.

They are also issued with gloves to protect the hands. These were worn when thought necessary, but often the workers chose to leave them in the vehicle cab. Since these can be put on and off with ease, they are only likely to be worn when the individual perceives a direct need to protect his hands. Thick or stiff gloves which making gripping bags more difficult are likely to be worn less than is ideal.

Related to the use of PPE against sharps, there appears to be a significant drugs problem in the city and crews were very aware of locations where they were likely to find discarded needles or bags containing discarded needles. It was apparent that the risk of blood-borne disease such as Hepatitis or HIV/Aids was of concern to them.

5.5. Physical fitness

The heart rate data that were recorded give an indication of how physically demanding the refuse collectors' work load is. Table 28 provides a summary of the data in Figures 62 to 66.

Table 28. Summary of heart rate data

Round type	Overall mean heart rate (<i>and individual values</i>)	Overall mean working pulse (<i>and individual values</i>)
Bags	106.5 (109, 104)	20.5 (21, 20)
Green wheelie bins	95 (94, 96)	20
Trade bins and sacks	101 (101, 101)	16.5 (14, 19)

Astrand and Rodahl (1986) classify workload leading to mean heart rates between 90 and 110 bpm as ‘moderate work’. This can be considered an acceptable level and is the category into which all the recorded heart rates fell. Similarly, the work pulses (the mean increase in heart rate when working) of around 20 bpm are not considered excessive. Action would need to be taken if these were greater than 40 bpm, i.e., twice the current values.

The data shows a trend towards the bags round leading to higher heart rates than the wheeled bin rounds. We do not have enough data to say whether this is a significant difference and the levels are still within the acceptable ‘moderate work’ category. However, this is an indication that a move towards replacing bags and small bins with wheelie bins would help to reduce the refuse collectors overall workload further.

6. MANUAL HANDLING RISK CONTROL METHODS

6.1. Changes to methods of refuse collection

The literature review showed from a number of perspectives that, wherever practicable, bags should be replaced with wheelie bins. One of the main reasons behind this is the higher metabolic demands of picking up, carrying and throwing bags compared to pushing and pulling bins. Heart rates, work loads and energy consumption were all found to be higher when collecting bags compared to collecting wheelie bins. Postures such as stooping and holding bags away from the body are additional reasons why, ideally, bags should be replaced by wheelie bins. The mean heart rate of the two operators collecting bags was 106 to 107 bpm whereas the mean heart rate for the green wheelie bin round and the trade round were 95 and 101 bpm respectively. Although we did not collect sufficient data to determine the significance of these differences, they show a trend that reflects the view in the literature that bag collection is the more physically demanding of the different types of refuse collection.

The round dustbins, although only handled occasionally in the area visited, are awkward to handle because of their size and shape. Also, the handles may not be well designed, thereby making the lifting and tipping of them more difficult, with potentially awkward wrist and arm postures. Emptying them into the lorry involves carrying then lifting a significant weight to head height or above and controlling the motion of the bin so that the refuse falls out but the bin doesn’t fall into the crusher. The introduction of black bags was intended to remove the need for handling them. The move from the very old steel bins to aluminium or plastic bins has significantly reduced the weights of the bins in circumstances where they do still need to be handled. It is likely that many householders will continue to use them as a storage container to hold the black bags, particularly since this is tidier than loose bags and prevents animals damaging the bags and spreading their contents when scavenging for food. In such circumstances it is simple for the refuse collector to remove the lid and lift the bag out of the bin, then replacing the lid. Handling of the whole bin is likely to occur only if the

householder has filled it with refuse but neglected to use plastic sacks. Because of the difficulties of handling and the greater weights, handling them represents a greater risk than throwing bags. Therefore, they should be removed from circulation as soon as possible and refuse collected in bags only, or the bags and small bins should be replaced with standard 240 litre wheelie bins.

It is likely that the use of such bins can never be completely eliminated but the manual emptying of them should only occur in exceptional circumstances. Therefore, a number of approaches could be adopted when they are found

1. Leave the bin full with a sticker attached informing the householder that refuse must be put into black bags before it will be collected.
2. Empty the bin but leave a leaflet or sticker asking the householder to use plastic bags.
3. Provide council officers with a list of persistent offenders so that letters can be written to them to ask them to use plastic sacks.
4. Empty the contents of the bin into a sack.
5. Manually handle the bin either singly, or for particularly heavy ones, in a team of two people.

The approach adopted will depend on the council. Options 1 to 3 above would require active management and authority wide implementation with strong management support for workers dealing with irate members of the public whose refuse had not been collected. Option 4 would require the provision of sacks for the workers to use. It would be easiest to implement in an area where refuse sacks were supplied anyway as part of the collection service. However, such a provision of sacks would tend to eliminate the problem since householders would not have the problem of providing sacks. Option 5 is the most likely to occur in the short term, especially since refuse collectors are likely to see themselves as strong individuals who should be able to handle the occasional dustbin. Moreover, the processes of self-selection into the job and attrition of the weaker individuals from the job will almost certainly lead to a healthy worker, survivor, effect.

However, if these bins continue to be used there are some ways of reducing the risks they present to collectors by using particular lifting techniques. One method would be to lift the bin onto the first available ledge on the back of the truck. The refuse collector could then lean the bin into the truck so that the top of the bin rests on the 'lip' of the main refuse space. He could then take hold of the base of the bin (which would be around waist height) and pivot it upwards with the top of the bin still resting on the main 'lip'. This would empty the bin without the need for the lifting of the full weight above shoulder height. It would also reduce the amount of twisting while lifting because the refuse collectors could stand directly behind the bin when lifting the base to tip out the contents.

6.2. Changes to the design of wheelie bins

Changes could be made to the wheels of the bins in order to reduce the strain of pulling wheeled bins over small obstacles and up kerbs. Given that there may still be cases where the bins need to be pulled up kerbs the wheels should ideally have a radius slightly greater than the (mean) height of a large kerb. This would allow them to be rolled up kerbs more easily by eliminating the initial vertical lifting element of the task. We did not take measurements of the wheels on the bins, but from the photographs there does appear to be potential for increasing the wheel diameter. Manufacturers would need to investigate appropriate dimensions during the design process.

Use of lightweight materials could be investigated by bin manufacturers. Given that the bins may sometimes need to be pulled up slopes, steps, kerbs and over obstructions, any reduction in basic bin weight would be of benefit to the refuse collectors. Manufacturers should be encouraged to look at ways of using new materials whilst maintaining the bins' current robust properties.

6.3. Work environment changes (lift height, kerbs, steps, etc.)

6.3.1. Lowering the rave rail on the refuse truck

The height of the rave rail at the rear of the truck determines how high bags must be thrown or lifted and how high the round dustbins must be lifted. This bar is set to the high position if wheelie bins are being collected. However, the current official practice is to leave it up, for 'safety reasons', even when only bags and small bins are being collected. We were not told the exact nature of this safety hazard and therefore can not make any judgements on whether it outweighs the increased manual handling risks of keeping the bar high. However, on the basis of manual handling alone, the rail should be dropped as low as possible when bags and non-wheelie bins are being collected. This would reduce the overall height that the refuse must be lifted to and would reduce the overall workload of the refuse collectors.

The other alternative would be to have lorries without the lifting gear on the bags rounds. In the city studied the lorries were allocated to specific rounds so this would be possible, even though all had the lifting gear fitted. This system has the advantage that if necessary any truck can be used on any other round, and if occasional wheelie bins are found on a bags round, then they can be dealt with mechanically. If necessary, because lifting mechanisms are bolted to the rear of the truck, typically with six bolts, it would be possible to remove the lifting gear in preparation for a bags round on any particular day.

6.3.2. Physical environment changes

As already discussed, wheeled bins should be transported across dropped kerbs wherever possible. The council should be encouraged to investigate where it would be useful to drop kerbs. Ideally, the refuse collectors should be involved in schemes to identify problem areas and recommend improvements. Improvements may not just involve dropping kerbs, but may also include provision of ramps to replace steps, resurfacing of alleys and pavements and removal of unnecessary obstructions.

6.3.3. Resident / proprietor involvement

In a number of cases we observed that refuse bags and wheelie bins were located some distance from where the refuse truck could be parked. This increases the distance that refuse must be carried, pushed or pulled, and potentially increases the number of hazards encountered when taking the refuse to the truck (steps, potholes, ridges, threshold boundaries, kerbs, etc.). Whilst in some cases this could not be avoided (wheelie bins in dedicated storage areas) there were other situations where the bins or bags or loose refuse were at the back of shops and buildings or down alleyways. In these situations it would be helpful if shopkeepers or trade proprietors or residents, brought their refuse to a more accessible location on the day that the collection round is made.

As with the issue of physical environment alterations, it would be good to involve the refuse collectors in a scheme of this kind. They will be able to identify problem locations and perhaps suggest ways of improving access to the refuse and bins. The action taken could be a blanket request to the relevant people highlighting the problems with refuse in places that are hard to access and ways that they could help. Alternatively, it may just be that particular premises / proprietors and owners are contacted with specific requests to help in whatever ways they feasibly can.

7. RECOMMENDATIONS

1. Wherever possible, refuse collection should be carried out using wheelie bins of appropriate sizes rather than bags or small dustbins.
2. As Government policy is to increase the amount of waste recycled, partly through the taxation of landfill, schemes that encourage householders to separate recyclable waste will become more common. Where recycling collections are made by local authorities or their contractors, separate wheelie bins should be provided wherever possible.
3. The schedules of recycling / no-recycling collections should be matched to the relative volumes of recyclable and non-recyclable material to keep the volumes collected approximately constant.
4. Where use of wheelie bins is impractical, collection of bags is likely to continue unless bulk collection facilities can be implemented. In these circumstances recycling should be encouraged by the provision of green bins and bags.
5. Old-style dustbins should never be emptied manually into refuse vehicles. Where householders still use them they should be encouraged to line them with black bags before putting refuse into them.
6. Eurobins should be:
 - a. Handled by two people whenever possible;
 - b. Transported across dropped kerbs wherever possible and particularly when being returned after emptying, which is when most of the pulling back up kerbs would usually occur.
7. When moving any size of bin the refuse collectors should:
 - a. Ensure there is sufficient space to manoeuvre the bin by moving surrounding obstacles, opening doors, etc.
 - b. Try to avoid pushing or pulling the bin across obstacles such as steps and kerbs.
 - c. Seek assistance when having trouble moving a bin - particularly if moving it up or down a slope or kerb or step.
8. Manufacturers should be encouraged to consider the following changes / aspects of the bins:
 - a. Increasing wheel diameter;
 - b. Use of lightweight materials - especially in the larger 360 and 1100 litre Eurobins.

9. Where possible, lorries without lifting gear and with a low rake height should be provided for rounds dealing solely with bags. Where the same vehicles are used for different rounds, consideration should be given to demounting the lifting gear the bags-only rounds.
10. Where lifting gear is fitted, the rake bar should be lowered when not collecting wheelie bins. This recommendation should only be ignored if specific safety risks that outweigh the manual handling risks of keeping the bar up can be clearly demonstrated.
11. The refuse collectors should be involved in a scheme with the relevant local authorities to identify areas where improvements could be made to their work environment. This would consider where kerbs should be dropped, ramps installed, alleys and pavements resurfaced and rubble or building waste cleared.
12. Refuse collectors and local residents / trade proprietors should all be involved in schemes to reduce the refuse collectors' workload. The refuse collectors could identify the premises and types of problems they face, e.g., fetching bins from the backs of shops, etc. Suggestions could then be made to residents / proprietors about how they can help.
13. Refuse collectors should be provided with effective PPE for their hands and legs. This would not only help reduce the risk of lacerations, infections and disease but it may also enable refuse collectors to grip, hold and carry refuse in optimal ways, i.e., held in a balanced way and not held so far away from the legs.

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