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An ergonomics evaluation of cashier work activities at checker-unload workstations

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The ergonomic suitability of the 'over-the-counter' (OTC) or 'checker unload' workstation for grocery-scanning operations has been questioned by a number of ergonomists, safety and health professionals, and retail food industry executives in the USA. There is concern that requiring cashiers to remove grocery items directly from the customer's cart for scanning exacerbates the risk of musculoskeletal disorders associated with this job. For this reason, a study was conducted to determine whether supermarket cashiers are exposed to increased biomechanical stress due to the use of checker-unload workstations for standing work. The work activities of 12 grocery cashiers from three supermarkets were recorded on videotape. Postures and movements associated with the scanning task were visually evaluated and compared with those of 10 grocery cashiers using a front-facing, customer-unload workstation examined in a previous study. The results indicate that use of the checker-unload workstation places additional stresses on the cashier beyond those imposed by customer-unload checkstands. Specifically, the task of removing groceries directly from the cart for scanning increases the frequency of long reaches, awkward shoulder postures, and lifts. These stresses can be mitigated by eliminating checker-unload operations and providing checkstands with conveyor belts for delivering groceries to the cashier. Implementing additional workstation modifications and encouraging cashiers to adopt alternative work practices also may reduce the frequencies of awkward postures and stressful motions associated with this checkstand design.

Keywords: musculoskeletal disorders, work posture, supermarket workers, checkstand design

The US retail food industry is one of the most competitive businesses in the world. According to the Food Marketing Institute (FMI), after-tax profit for the industry ranged from 0.71 to 1.12% in 1986–1991 (Anon, 1992). Traditionally, grocery store operations have depended on increasing volume to compensate for low profit margins.

One strategy used by some grocers to attract shoppers into their stores is to provide additional services to their customers. In 1991, the number of US grocery chains turning to customer service as a competitive strategy increased by 53% over 1990 (Sansolo and Garry, 1992). Although customer service can take many forms, it is one reason commonly cited by retailers for the popularity in some markets of the *over-the-counter* (OTC) or *checker-unload* workstation (Thayer, 1989).

Despite the nearly universal use of 'standing' check-out equipment in the USA (as opposed to the 'seated' checkstands used throughout Europe) checkstands can vary enormously from store to store. One major source of differences is whether the store employs a customer-unload or a checker-unload operation. In customer-unload operations, customers transfer grocery items from a cart to a conveyor belt, which transports the groceries to the checker for scanning. In checker-unload operations, the front-end conveyor belt is eliminated from the checkstand; the cashier removes grocery items directly from the customer's cart for scanning (*Figure 1*). In addition to allowing the store to provide an extra level of service to the customer, checker-unload workstations generally take up less space than customer-unload designs. Recently, the Food Marketing Institute (FMI) estimated that 14.8% of retailers in the USA employ checker-unload workstations (FMI, 1990).

Recently, the ergonomic suitability of the checker-unload workstation has been questioned. Since 1989, the checker-unload workstation has been the subject of at least one US Occupational Safety and Health Administration citation for 'general duty clause' violations (Washington Industrial Safety and Health Administration, 1989). Problems ascribed to the

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Figure 1 Checker-unload workstation

checker-unload design include the following (Herrin, 1991):

- High forces and awkward shoulder and trunk postures are required to align grocery carts with the checkstand counter.
- Extended reaches and repeated lifts are required to remove grocery items from the cart for scanning.
- Awkward shoulder and trunk postures are required during scanning and keying tasks.
- Excessive wrist flexion is required during scanning tasks.

There is increasing evidence to suggest that musculoskeletal disorders are common in the US retail food industry (Margolis and Kraus, 1987; Baron *et al*, 1991) It is also well established that postures that overload muscles and tendons, load joints in an uneven manner, or require prolonged static muscle contraction, can result in fatigue, pain or injury (Corlett and Bishop, 1976; Hagberg, 1984, Westgaard and Aaras, 1984). Because workstation design can significantly affect working posture, checkstand design has been implicated as a contributor to musculoskeletal injury among cashiers (Ohara *et al*, 1976; Lannersten and Harms-Ringdahl, 1989; Harber *et al*, 1992). It is notable that it is not clear that the problems ascribed to the checker-unload design are unique; awkward postures and excessive static loading have been associated with a number of other checkstand types (Rodrigues, 1989; Grant *et al*, 1993). Consequently, the objective of this study was to determine whether the checker-unload design imposes *additional* biomechanical stresses on cashiers beyond those imposed by other checkstand designs.

In response to industry concerns, an ergonomics evaluation of cashier work activities was conducted at three supermarket chains in the Midwest USA. The postures of 12 grocery store cashiers using one of three checker-unload workstations were compared with postures of 10 cashiers using a front-facing, customer-unload design, examined in a previous study (Grant and Habes, submitted for publication). This comparison was performed to test the hypothesis that the checker-unload design is associated with a higher frequency of awkward postures and forceful movements during grocery-checking tasks. If so, the risk of musculoskeletal disorder development may be increased among cashiers using this design.

Methods

Store descriptions

This investigation was conducted in three grocery stores in the St Louis metropolitan area. Although each store featured a somewhat different checkstand configuration, all stores required the cashier to unload the customer's cart for scanning. A detailed description of each store is provided below.

Store 1 is a large supermarket operated by a privately owned chain (14 stores) in the St Louis area. The chain employs 3000 workers, of whom 350 are cashiers.

The checkstand used in this store was custom-built according to company specifications, but similar to other front OTC designs found in the industry (*Figure 2*). The checkstand incorporates a horizontal scanner positioned directly in front of the cashier. A scale is located to the cashier's left, approximately 40 cm above counter height. The keyboard is located above the scanner and is adjustable in height. During the transaction, the cashier and customer stand facing each other from opposite sides of the counter, with the grocery cart positioned directly in front of the scanner

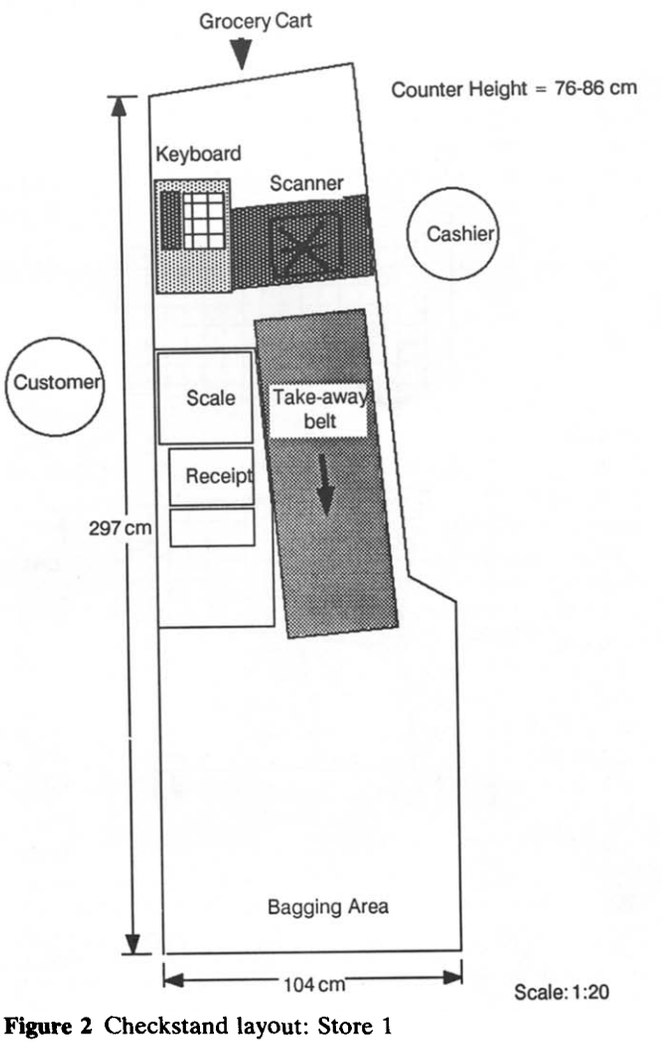

Figure 2 Checkstand layout: Store 1

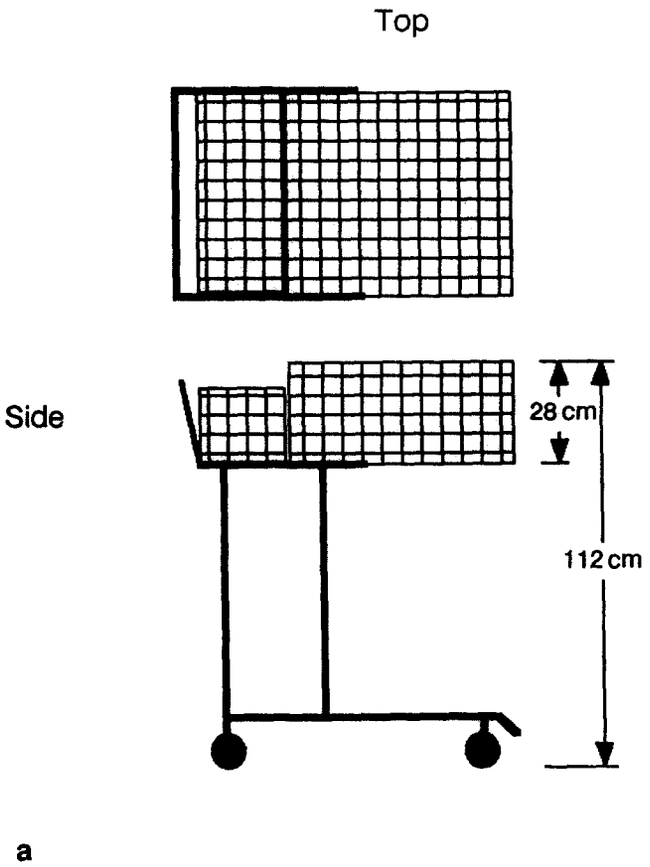

Figure 3 Grocery cart dimensions: (a) OTC cart; (b) conventional cart

on the cashier's right side. Grocery carts specifically designed for checker-unload operations (OTC carts) were provided for customer use. These carts are taller and shallower than conventional grocery carts (*Figure 3*), and at this store can be pulled over the top of the grocery counter to bring items nearer to the scanner.

Ten months prior to the evaluation, a training programme was developed and implemented by store management to address concerns about potential ergonomics problems related to scanning. The programme was designed to provide all cashiers with training in proper scanning methods. Cashiers were required to watch a 15 min videotape and undergo a 15 min practice session with a trainer. Cashiers were instructed to: (1) pre-position (or 'stage') grocery items near the front of the cart to reduce reach distances during scanning; (2) drag items across the scanner after removing them from the cart; and (3) key in items after three failed scanning attempts. Cashiers were monitored periodically to ensure conformance with these procedures.

Store 2 is operated by a chain of 62 supermarkets located in the Midwest. The chain employs approximately 14 000 workers, of whom 5000–6000 are cashiers.

The checkstand employed in Store 2 was a Reynolds 4000, 90° right-hand takeaway (RHT) design with a horizontal scanner (*Figure 4*). In most applications, the Reynolds 4000 is paired with a conveyor module to provide grocery items to the cashier for scanning; however, in this instance the conveyor module was not provided with the design. Instead, the cashier stands

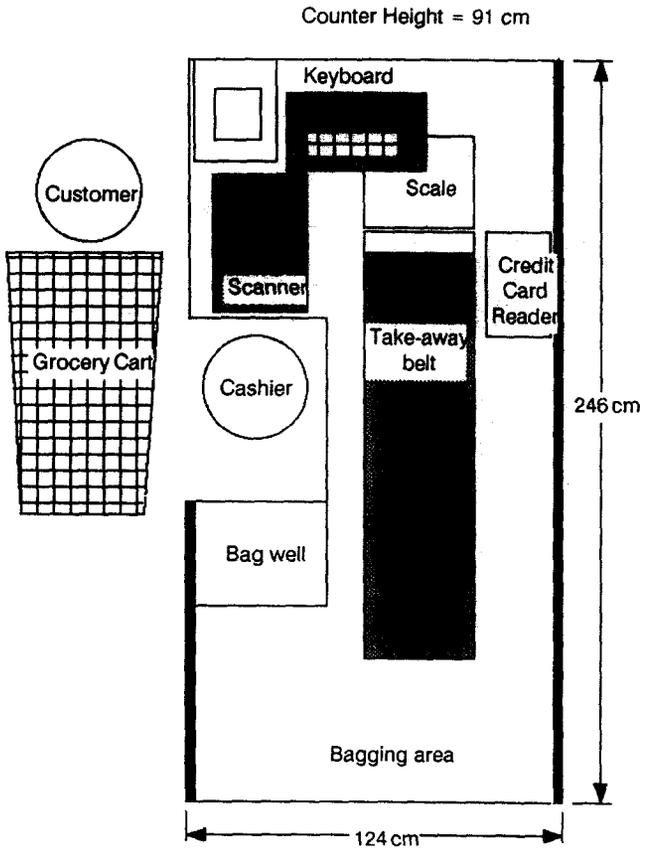

Figure 4 Checkstand layout: Store 2

directly in front of the scanner with the grocery (conventional) cart located to the cashier's left. The cashier removes items from the cart, lifts and/or drags them across the scanner and places them on a take-away belt located on the cashier's right side. A scale is also positioned to the right of the scanner.

Store 3 is operated by a 57-store supermarket chain in the Midwest. The chain employs 8000 workers, including approximately 2000 cashiers.

The checkstand examined during this investigation was a Reynolds 2100/2200 Scan OTC model with a vertical scanner/scale. Except for the scanner/scale, the checkstand was similar to the model used in Store 1. OTC carts were provided for customer use; however, the bed of the cart was approximately 8 cm lower than the checkstand counter. An illustration of the checkstand and its dimensions is shown in *Figure 5*.

Site visits were conducted at each of the three stores on a typical workday. During the site visit, the work activities of four cashiers at each location were observed and recorded on videotape using hand-held cameras, from at least two angles (perpendicular to the cashiers' sagittal and frontal planes). The investigators did not attempt to alter the work habits of the cashier or the actions of the customers. Because cashier work style might be influenced by such factors as fatigue, customer demands and store busyness, cashiers were observed and videotaped for short (10–15 min) periods occurring randomly throughout a 2–3 h monitoring period. Each cashier was filmed for a total of 30–45 min.

Comparison group. The postures of the grocery cashiers examined in this study were compared with the postures of 10 cashiers using a Reynolds Data 3000 Series front-facing, customer-unload checkstand with a vertical scanner/scale examined in a previous study (Grant and Habes, submitted for publication). The front-facing checkstand (*Figure 6*) is similar to the checker-unload designs examined in this study, in that the cashier stands directly behind the scanner and keyboard, facing the customer; however, grocery items are delivered to the cashier's right side on a conveyor belt rather than in a cart. Both groups of cashiers (checker and customer unload) were similar in terms of gender (three men in checker-unload group, four men in customer-unload group), age, experience, and the size and location of the store where they were employed. All data were collected and evaluated using the methods described above and below.

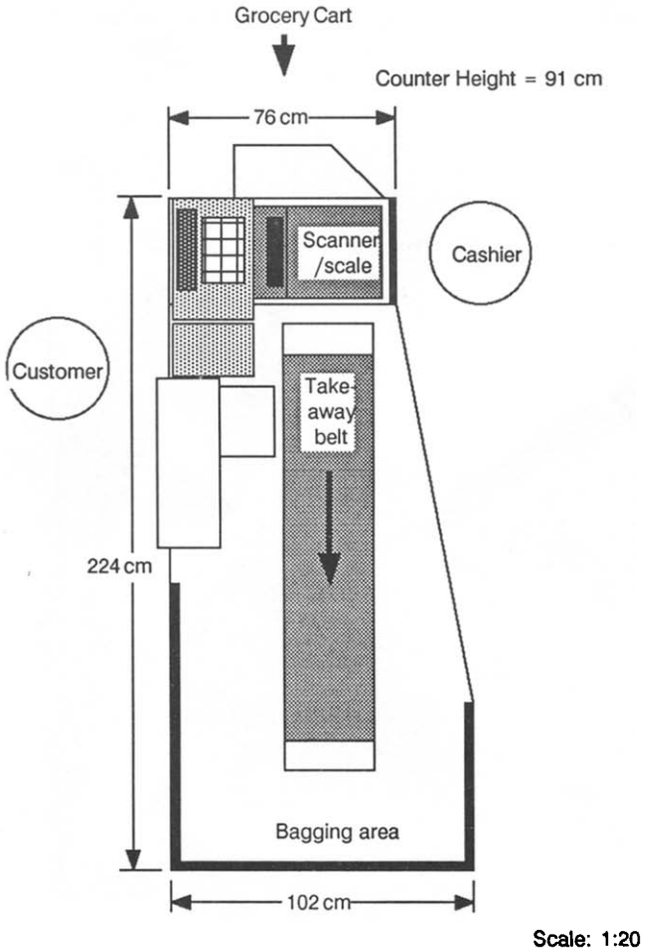

Figure 5 Checkstand layout: Store 3

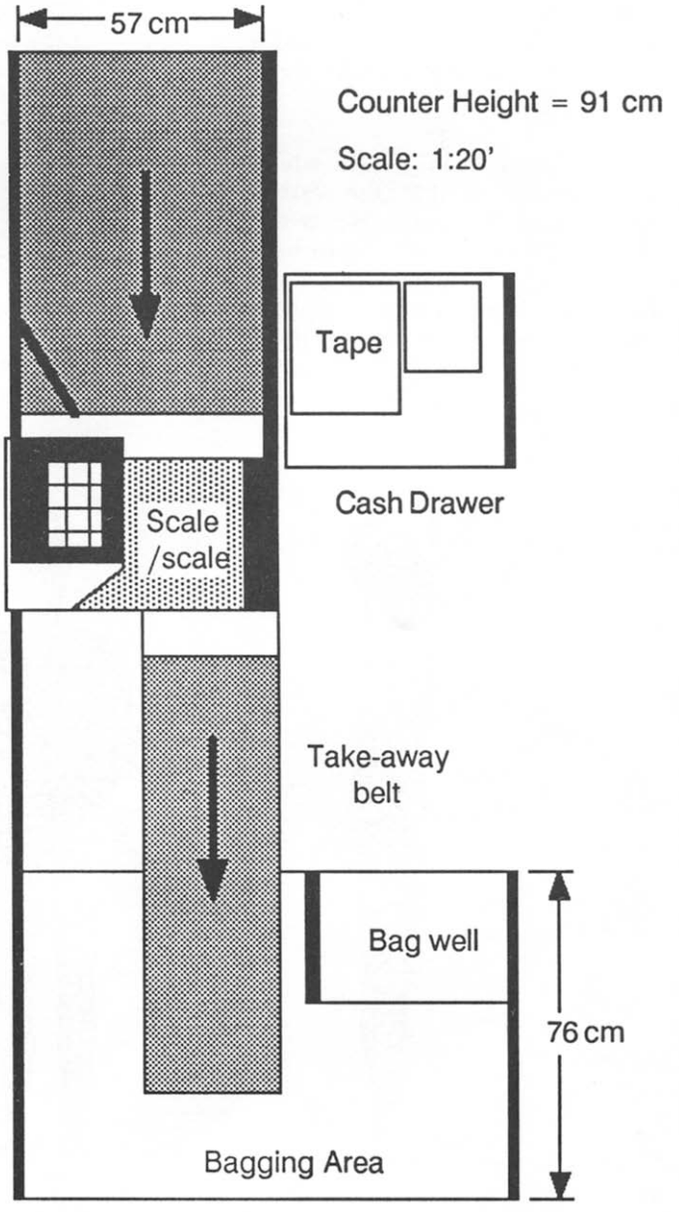

Figure 6 Comparison checkstand (customer unload)

Posture classification system

To identify potential exposure effects associated with unloading groceries from the customer's basket, an analysis of cashier upper extremity and trunk postures during grocery-scanning activities was performed. The analysis focused on the following scanning postures.

Initial reach. Biomechanical principles suggest that the workstation design should enable a working posture in which the elbows are not elevated above mid-torso height: that is, the shoulders are neither flexed nor abducted more than 60° (Armstrong *et al*, 1986). Similarly, the workstation layout should allow the trunk to be maintained in an upright, neutral posture, neither flexed, bent nor twisted more than 20° (Keyserling, 1986). Therefore, the posture of the trunk and shoulder at the initiation of each scan were evaluated as follows:

- shoulder flexion – coded only if flexed more than 60° at the time of initial grasp (*Figure 7a*);
- shoulder abduction – coded only if abducted more than 60° at the time of initial contact with the grocery item (*Figure 7b*);
- trunk posture – coded if flexed more than 20° at the time of initial contact with the grocery item (*Figure 7c*).

Motion across scanner. An advantage of the vertical scanner/scale is that the cashier is able to slide rather than lift items across the scanner, thereby avoiding forceful exertions with the hands and fingers (Grant *et al*, 1993). However, if removing grocery items from the customer's cart requires the cashier to lift grocery items to the scanner, this advantage is eliminated. Therefore, the motions used by cashiers to pass items across the scanner were coded to determine whether the cashier-unload practice increased the occurrence of lifts associated with scanning. For each item, the rater noted whether the object was 'lifted' across the scanner, with the full weight supported by the arm, or 'dragged' across the scanning surface (Harber *et al*, 1992). A third category, 'half lift/half drag', was defined for instances where the cashier lifted the object to the scanner, but then dragged it across the surface of the scanner to the adjoining conveyor, or vice versa.

Videotape segments were reviewed by one of the investigators (KG or DH), and the motions and postures used by the cashier to scan grocery items during each segment were visually evaluated and coded. To ensure that the observed sample of scanning postures was representative of the cashier's normal activities, a sufficient number of 15 min segments was analysed so that each cashier was observed scanning approximately 200 items (mean = 205). Each investigator (KG and DH) evaluated an equal number of film segments from each store to assure that rater bias did not affect the results. In addition, 25% of the tape was analysed independently by both investigators. Comparison of the ratings indicated good consistency between raters (minimum correlation coefficient = 0.912), although there was a systematic tendency for one investigator to code a larger number of shoulder postures as awkward. At the conclusion of the analysis, the relative frequency (percentage score) of each posture (trunk and shoulder) and motion was calculated for each cashier, using the total number of scans observed as the denominator.

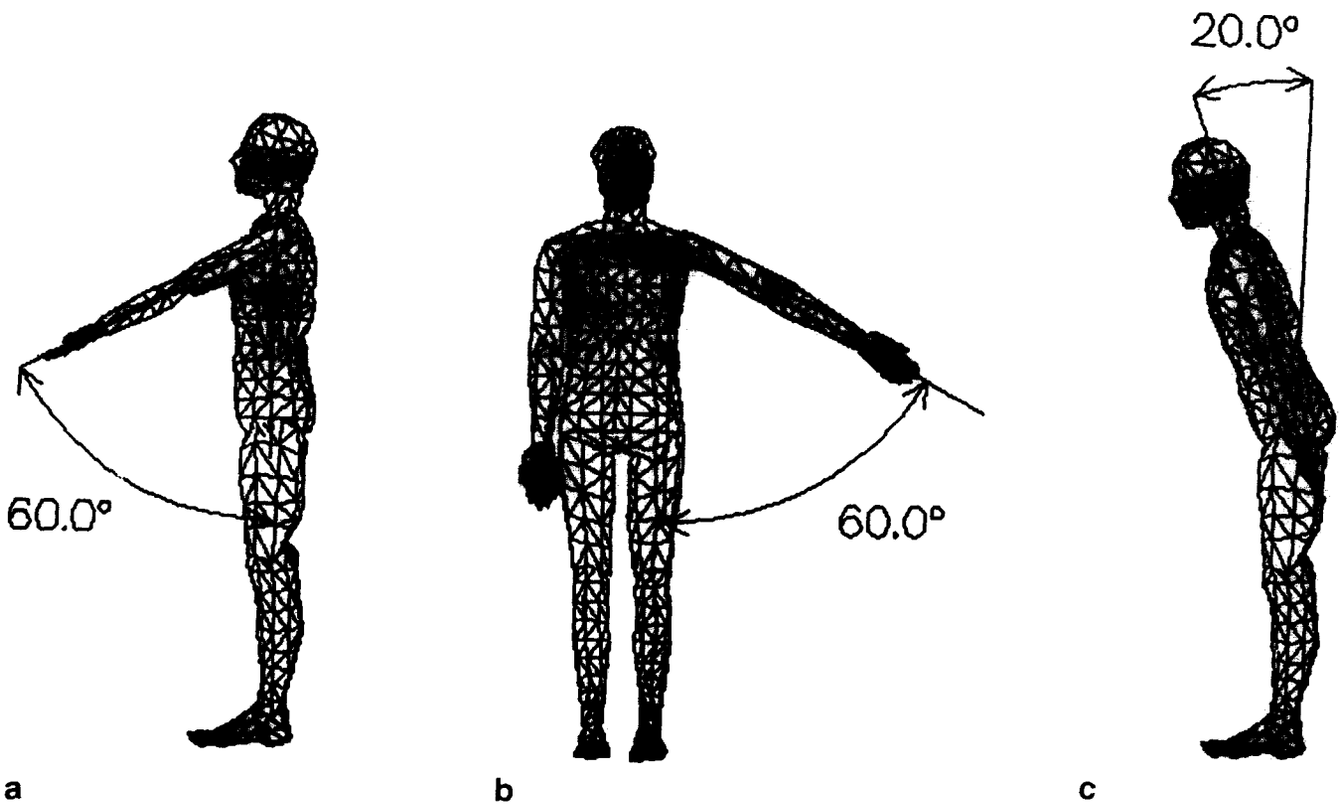

Figure 7 Postures evaluated: (a) shoulder flexion; (b) shoulder abduction; (c) trunk flexion

Statistical analysis

One-tailed *t*-tests were used to determine whether cashiers using the checker-unload designs displayed significantly higher frequencies of awkward trunk and shoulder postures and lifts, and a significantly lower frequency of drags, than cashiers using the customer-unload design. To obtain homogeneity of variance, arcsine transformations were applied to the data (Myers, 1979). All computations were performed using SAS Release 6.04 (1988).

Results

As shown in *Table 1*, awkward shoulder and trunk postures were observed among cashiers at all three stores using the checker-unload designs examined in this study. The table indicates that cashiers who remove items from a cart for scanning exhibit a significantly higher percentage of awkward trunk postures ($t(20) = 2.17$, $p < 0.05$), and awkward shoulder postures ($t(20) = 1.74$, $p < 0.05$), than cashiers who remove items from a conveyor for scanning. Furthermore, while requiring the cashier to remove items from the cart did not affect the frequency of 'pure' lifts observed during scanning, the frequency with which cashiers were required to lift the item at *some point* during the scan (half-lift) was dramatically increased ($t(20) = 3.38$, $p < 0.01$) among cashiers using the checker-unload design. Alternatively, the frequency of drags among this group was significantly reduced ($t(20) = 7.23$, $p < 0.01$).

Checkstand design, differences in work technique, and grocery cart design all appeared to influence the frequency of awkward postures and forceful movements observed during scanning. Design problems specific to certain checkstand features are discussed below.

Store 1

Examination of *Table 1* reveals that the frequencies of awkward shoulder and trunk postures demonstrated by cashiers using the OTC equipment in Store 1 are similar to those observed among cashiers using customer unload checkstand designs (33% vs 35%, and 17% vs 18%). The lack of difference in the frequency of awkward shoulder and trunk postures probably can be attributed to the worker's practice of pre-positioning, i.e. 'staging', grocery items for scanning. Cashiers were observed to stage approximately one-third (34.7) of all grocery items for scanning. Although staging reduces the frequency of awkward postures *during the scanning process*, it probably has no effect on the *overall* occurrence of awkward shoulder postures, and may actually increase the cashier's workload owing to added muscular efforts not revealed in this analysis. Staging requires cashiers to handle grocery items twice: once to move them forward in the cart and once to pass them across the scanner. Awkward shoulder postures were almost always observed during the staging process, as cashiers had to reach over the side of the cart (30 cm high, top edge = 112 cm above floor) to gather items near the back or on the opposite side of the cart. Because these reaches were not considered in the analysis scheme (as they did not occur during 'scanning' *per se*), the percentage of awkward shoulder postures calculated for cashiers in Store 1 (*Table 1*) may not accurately reflect the actual frequency of awkward shoulder postures experienced by these cashiers.

Other factors that appeared to influence the posture of the cashier during scanning tasks included the location of the scale (117 cm above floor height, 43 cm from the edge of the checkstand), which caused the cashier to lift objects above shoulder height during weighing tasks, and the practice of allowing customers to store large grocery items on the bottom of the shopping cart. Removing bags and boxes from the bottom of the grocery cart frequently required awkward bending and reaching (*Figure 8*). The bottom shelf of the cart is 15 cm above floor height; a second shelf is located near the front of the cart, approximately 36 cm above floor height. Depending on the location of the object, the object's weight and the posture the cashier assumes during the lift, the lift may put excessive biomechanical stress on the back.

Store 2

As indicated in *Table 1*, the checkstand/grocery cart design used in Store 2 required the cashier to lift every

Table 1 Postural analysis results for cashiers using checker- and customer-unload workstations

	Mean items/ checker	Scan motion (%)			Shoulder flx/abd (%)	Trunk flx (%)
		Lift	Half	Drag		
Store 1 ($n = 4$)	219	19.0	78.5	2.5	33.4	17.0
	(33.6)	(6.3)	(8.3)	(2.7)	(16.7)	(12.1)
Store 2 ($n = 4$)	172	37.3	62.5	0.0	53.9	55.0
	(67.1)	(34.4)	(34.0)	(0.0)	(6.6)	(8.8)
Store 3 ($n = 4$)	224	24.6	75.4	0.0	55.4	25.6
	(12.5)	(4.8)	(4.8)	(0.0)	(6.2)	(2.4)
Checker unload	205	26.9	72.1[a]	0.8[a]	47.6[a]	32.5[a]
($n = 12$)	(46.7)	(20.0)	(19.8)	(1.8)	(14.4)	(18.7)
Customer unload	290	27.7	49.7[a]	22.6[a]	34.9[a]	17.7[a]
($n = 10$)	(69.8)	(15.1)	(7.3)	(13.5)	(19.5)	(8.5)

Standard deviation indicated in parentheses.
[a]Indicates that difference between checker and customer unload is statistically significant ($p \leq 0.05$)

Figure 8 Cashier removing items from cart bottom (OTC cart)

grocery item at some point during the scan (that is, the design does not allow the cashier to drag grocery items across the scanner). This means that at some point during the scan, the full weight of each grocery item was supported by the cashier's hand and arm, even if the motion was classified as a half lift/half drag. Because the design does not permit the cashier to drag items across the scanner, the manual force requirements of the scanning task are greatly increased.

Furthermore, compared with cashiers using customer-unload checkstands, the frequency of awkward shoulder and trunk postures observed among cashiers at Store 2 was increased substantially (54% vs 35% and 55% vs 18%). This increase was observed mainly because the cashier was forced to lift items from the bottom of the grocery cart (51 cm above floor) to the scanner (91 cm above floor). This manoeuvre results in prolonged flexion of the spine during scanning, as well as repeated asymmetric lifting (*Figure 9*). This posture was demonstrated by all cashiers on *almost every customer order*, as grocery items are placed on the bottom of the cart first. If the customer order was very large, cashiers generally had easy access to items located near the top of the cart.

Store 3

As stated previously, an advantage of the vertical scanner/scale is that the design allows the cashier to drag rather than lift items across the scanner, thereby avoiding forceful exertions with the hands and fingers. Frequent and highly forceful hand exertions have been linked to the development of tendinitis, tenosynovitis and carpal tunnel syndrome (Putz-Anderson, 1988). Despite the design advantage provided by the scanner in Store 3, no scans that met the definition of a drag were observed, generally because the 8 cm height difference between the bottom of the cart and the checkstand counter required cashiers to lift items from the cart.

Long reaches, resulting in awkward shoulder and trunk postures, were observed frequently when the cashier was required to retrieve items from the back of the grocery cart (*Figure 10*). The frequency of awkward shoulder posture was more than 50% greater than that reported among grocery cashiers using front-facing (customer-unload) checkstands (55% vs 35%). Awkward lifts also were observed when the cashier was forced to retrieve large or heavy items (such as detergent boxes or cases of soft drink) from the bottom of the grocery cart.

Discussion and conclusions

Despite the fact that our study is based on a relatively small sample of cashiers (selected to represent the population of grocery cashiers who use checker- and customer-unload checkstands in the USA), the results have several important implications. First, the results of this study, on standing cashiers only, indicate that the checker-unload design imposes biomechanical stresses on the cashier beyond those imposed by customer-unload designs. The results suggest that a substantial reduction in the frequency of awkward trunk postures, and an increase in the frequency of drags, could be realized by providing grocery items to the cashier on a conveyor belt rather than in a cart. In general, representatives from each of the supermarket chains included in this study indicated reluctance to implement this strategy. Retailers expressed the opinion that having the cashier unload groceries for the customer was a service that helped attract customers to their store, and a service that customers in the area had come to expect.

Second, even if the checker-unload workstation is not eliminated, it appears that the magnitude of the loading effect can be modified somewhat by the layout of the checkstand components. A recent study of two customer-unload checkstands indicates that checkstand layout can affect posture substantially during scanning tasks (Grant and Habes, submitted for publication). Although all three checker-unload workstations had common design features (for example, the scanner was located directly in front of the cashier in all three designs), slight differences in the layout of the checkstand and the interface with the grocery cart probably explain some of the postural differences manifested between cashiers using these designs. The present results suggest that the following measures may reduce

Figure 9 Cashier removing items from cart bottom (conventional cart)

Figure 10 Examples of extended reaches during scanning

the biomechanical load on cashiers using checker unload workstations.

- *Match the height of the cart with the height of the checkstand.* Dragging grocery items across the scanner face is virtually impossible when the bottom of the grocery cart is lower than the checkstand counter. One reason that cashiers at Store 1 were able to drag items across the scanner (albeit the percentage was small) was because it was the only store that provided a cart slightly higher than the checkstand counter. Providing a cart that is slightly taller than the checkstand counter also allows the cashier to pull the cart in closer (over the counter) to reach items located in the back of the cart.
- *Provide special grocery carts designed for OTC use.* In general, conventional (deep) grocery carts are simply not suitable for OTC use. Requiring the cashier to unload grocery items from a conventional cart virtually ensures that the cashier will be forced to adopt awkward lifting and reaching postures to retrieve items from the bottom of the cart. Admittedly, one disadvantage of the OTC cart is that it cannot hold the volume of groceries of a conventional cart. This is one reason customers frequently use the bottom shelves of the OTC cart as storage space. This practice is problematic not only because it forces the cashier into awkward postures and lifting situations, but also because the cashier may forget to scan items stored in these areas. One possible solution, designed by Load King Manufacturing Co. (Jacksonville, FL), is a cart that mates with a mechanism in a specially designed counter. The mechanism, which the cashier controls with a foot pedal, raises the bottom of the cart as the cart is unloaded (Thayer, 1989). Because of this feature a deeper cart, with greater volume, can be used.

  Additional modifications to the cart could reduce the cashiers' reach to groceries located in the back of the cart as well. For example, mechanisms such as a spring-loaded plate attached to the back portion of the cart, or a conveyor belt located in the bed of the cart and engaged by a device in the checkstand counter, could be provided to move groceries toward the cashier as groceries are removed from the cart for scanning (that is, perform 'staging' automatically). Like staging, these modifications may reduce the frequency of awkward trunk and shoulder postures associated with the unloading task.
- *Locate scales immediately adjacent to the scanner, or provide a combined scanner/scale.* This recommendation applies to the design of all grocery store checkstands, customer- and checker-unload alike. Designs that incorporate the scale in the design of the

scanner, or provide a scale immediately adjacent to the scanner, are less likely to require extended reaches and lifts during weighing tasks, and may reduce the risk of back and shoulder strain.

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