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THE MANUAL HANDLING OF CHILDREN: A 24-HOUR EXPOSURE

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ABSTRACT

It was hypothesised that the manual handling - lifting and lowering - of children by their mothers might be a contributing factor in the development of back pain in women; a model was created to try and ascertain the cumulative effects of this manual handling. The frequency of lifts of children of three different ages (7 months, 2.5 years and 4.5 years) was determined by questionnaire and the mother's L5/S1 disc pressure during some of these lifts was measured using the 3 Dimensional Static Strength Prediction Programme. The results were compared against the same parameters for nursing aides performing pulling/turning tasks at work and against the NIOSH Guidelines.

The highest L5/S1 disc pressure in the mothers group was 2094 N and the average was 860 N. However, based on the author's model, the cumulative effect of the mothers' tasks indicated similar and higher load levels during periods with three small children, compared to the nurses' levels. These results suggest that the total manual handling of children by mothers, measured this way, is substantial and might indeed be a contributing factor to low-back pain in women. It was further indicated that, for a majority of the female population, the shoulder/neck region may not have sufficient strength to cope with some of the manual handling tasks involved.

1. BACKGROUND

1.1 Introduction

The manual handling involved in mothering encompasses a range of activities some of which directly involve the child and others which are peripheral to him. Most of the tasks, for example, lifting and carrying the child, or lifting and carrying the nappy bucket, cause stress to the lower back. However, the physical demands of the unpaid labour of child-rearing have attracted little attention from the researchers of ergonomics or physiology and the physical aspects of this workload have not been measured. The possible contribution of this workload in the incidence of back problems in working women has therefore probably been neglected.

This issue gains importance as increasing proportions of Australian women are employed in paid work. In 1992 59% of women in Australia were in the labour market and the number of single parents was around 15% and rapidly increasing (Hammarström & Hammarström, 1991; 1992). In a country like Sweden, 85% of women have paid work, and the problem of the "double" exposure for women - to hold a full-time or part-time job while still doing most of the work at home - has been discussed since the 1960's (e.g. Edgren, 1978).

For paid employment - "work" - there are numerous assessment methods which can be applied to determine, for example, the aerobic uptake and energy cost, the pressure on the L5/S1 disc, or the mental workload of the tasks; the results are then reviewed against guidelines and recommendations to ascertain

the stress/strain/risk involved in performing these tasks. There have been few applications of these measurement techniques to the home environment. A number of studies on the physical workload of cleaning and housework have been completed (e.g. Linn, 1985; Grandjean, 1973) but none have been applied to the manual handling involved with young children.

The objective of this study was

- to describe the manual lifting and lowering of children performed by mothers,
- to assess a number of the child-related manual handling tasks in terms of biomechanics,
- to compare the obtained results with some industrial guidelines,
- to compare the results against the analysis of female nurses lifting patients,
- to assess the total workload involved in the manual handling of children over time, and discuss the possible role in the occurrence of low back problems.

The literature was reviewed for information relating to musculo-skeletal injuries amongst mothers and the physical demands of child-related manual handling tasks. Similar information on the manual handling involved in professional nursing was sought.

1.2 The Manual Handling of Children

The manual handling of children changes with time. At their youngest, children are completely helpless. As they grow in size and weight, and gain better control over their body movements, they also go through stages of assisting and resisting the performance of everyday routines such as nappy changing.

The manual handling tasks involved in the care of children up to the age of approximately 2 1/2, are much the same, they need help with virtually all the activities of daily living: two and a half year olds may still not be toilet-trained, nor be able to bathe, nor dress themselves. During this time, as their physical capabilities develop, enabling them to roll, sit unsupported, lift their limbs upon request and stand, the parameters of the tasks change as the working posture adopted by the mother is partly determined by the physical level of the child. The young baby that can only lie necessitates the mother leaning to reach all parts of the child. When the child can sit, he has come nearer and higher to the mother, effectively raising her working height and lessening the forward reach. However, the weight she lifts has also increased.

Babies/toddlers are constantly lifted and carried: into and out of cots, highchairs, baths, baby capsules for the car, laps, shopping trolleys, prams, from and onto the floor and change tables, carried until they have settled/been burped/gone to sleep/ the danger from siblings has passed, they are nursed and cuddled. The lifting and carrying is often not done according to the principles suggested in the Regulations and Code Of Practice for Manual Handling (1988). It can be asymmetrical, the child can be lifted and lowered some distance from the lifter and he/she can be a writhing, resistant object - these are some of the aspects which can compound the difficulty of the tasks. The style and types of lifts will of course vary between individuals - whether a bed or change table are used, how much the child is carried etc - but caring for a child necessitates a certain level of physical work. Obviously, as the child becomes more independent, the number of lifts the mother does lessens: by four and a half, most of the lifting done is during play.

Preparation for motherhood probably does not include an ergonomic consideration of the oncoming workload - the health and well-being of the pregnant woman are the concern of midwives, obstetricians, physiotherapists and the like, the mother's attitude towards the upbringing of the child is influenced by her own childhood environment and her interest in this aspect, but how the mundane, day-to-day physical chores that are part of the job of child-rearing are actually carried out is not much discussed .

The design and style of equipment (prams, highchairs etc.) and therefore the range available to choose from, is also possibly determined more by economics and aesthetics - and cultural traditions - than by ergonomics.

Mothers do not work regular shift-work, or rather, they regularly work irregular shift hours. Some children sleep through the night from an early age, others will need attention up to several times per night, on and off for a few years.

2. LITERATURE REVIEW

There have been many studies describing the relation between occupation and low-back pain, for example, Andersson (1981) and Troup (1981). Worksafe Australia (1986) quotes figures from the United Kingdom where, in 1979, 61% of over-exertion injuries occuring at work were of the back. However, it appears that no one has measured what effect the manual handling of children has upon the prevalence of back disorders in women.

Troup (1985), in a paper on lumbar spine and musculoskeletal morbidity, also mentions that the musculoskeletal disorders have a multifactorial aetiology and that one factor that should be considered is the workload at home "particularly (for) females in employment".

Videman et al (1984) tried to determine some of the factors leading to low-back pain in nursing aides and qualified nurses. They sent a questionaire to a random sample of nurses in Finland and received answers from 318 nursing aides and 562 qualified nurses. The number of childbirths was found to be related to the prevalence of sciatic pain. The authors commented that the "domestic work-load, particularly following childbirth" may indeed strengthen the relation between the physical workload at work and low-back symptoms.

Larsson et al, (1990) also found a correlation between number of children and the development of musculo-skeletal problems. They attempted to determine if there were any predictors that could be routinely used in the claims settling of occupational overuse disease. They randomly chose 100 women, aged between 30 - 45 years, who were registered with the Social Insurance Office, and had been off work for between 2 and 4 months with a neck/shoulder problem. Fifty-one of these women agreed to participate in the study. They were medically examined to establish a more precise diagnosis than that given on the work certificate and reclassified into "neck/shoulder" or "other" to better ascertain the variables relevant to women with neck/shoulder problems. An evaluation of their worksite was then carried out by an ergonomist. One of the two variables highlighted was the number of children they had: there was a greater proportion of women with three children in the "neck/shoulder" group than in the "other" group: 35% compared to 11%, while for women with 1 or 2 children the proportion was 61% compared to 76%, suggesting that having three or more children may have an interaction with women developing neck-shoulder problems.

Mital, in 1984, reported on the maximum acceptable weight of lift, for both men and women, during an 8-hour work-shift. In his study he had 37 males and 37 females lift 3 different weights to and from 3 different heights at 3 different frequencies. He also compared the 8-hour and 12-hour shifts with respect to the weight the workers were willing to lift and concluded that women accepted a weight that was 12% lighter for the 12-hour shift than for the 8-hour shift. The study also showed that, of the different lifts in the two shifts, the greatest oxygen consumption occured for the floor to knuckle height lifts during the 12-hour shift. Mothers, especially of very young children, frequently perform this height lift and certainly work a 12-hour day.

In their study in 1990, Louhevaara et al aimed to quantify the local muscle and circulatory strain that occured during different types of manual handling. They had a small sample of 6 men and 6 women, aged between 23 and 41 years, who, in a laboratory situation, lifted, carried and held a 4 kg. parcel, while the E.M.G. readings for M. brachioradiulus, trapezius, erector spinae (L3 level) and semi-tendinosous were taken. Some interesting points came from the study. Firstly, the mean maximum work time was 7.6 minutes for the load holding task, and although the method of holding the parcel in the study (upper body bent forward 30^{o}, load in both hands and arms straight down) was different to the way many women hold their young child (load close to body and back position flexed or straight or flexed sideways), there is still some applicability to our task. Secondly, the M. erector spinae E.M.G. readings showed that the highest static contraction levels occured during the holding task, rather than the carrying or lifting. These points suggest that prolonged holding of the child while the mother is standing could be one of her more demanding tasks. Thirdly, that during the lifting task, the M. erector spinae exceeded the median limit of 14% M.V.C. (maximum voluntary contraction), which may indicate that even a 4 kg. load can demand a lot of effort from the back muscles.

Mital and Kromodihardjo (1986) had 4 male volunteers perform 12 different lifts to allow the compressive and shearing forces generated on the spine to be analysed. The 12 lifts consisted of the

combination of 3 different sized boxes, 2 couplings (handles vs. non-handles) and 2 types of lift (symmetrical vs. non-symmetrical). The weight of the lift was determined by the subject and the frequency was 1 lift per 30 minutes. As it was a small sample, the authors did not make any statistical inferences. The results seemed to confirm the obvious: that people would lift heavier weights when handles were present, that they accepted less weight as the size increased and that an asymmetrical lift was more difficult and performed more slowly than a symmetrical one. These points could be relevant to the lifting of a child that increases in weight over time: children being the living, moving creature that they are, do not present with ready handles nor stay in the most ergonomically advantageous position for the person lifting, thereby possibly making the lift more difficult.

Linn (1985) examined bathrooms in Swedish households with respect to their being cleaned. She established the problems associated with the cleaning by observing the cleaning techniques of the occupants of 10 different households and interviewing 5 home-help workers. She then carried out a laboratory study where 9 subjects cleaned various styles of toilets, handbasins and bathtubs over several days and compared the postures adopted. Linn concluded that "if our bathrooms were regarded as a work environment for home-helpers they would certainly be deemed unsatisfactory." Perhaps some childcare equipment and home environments are as poorly designed as the bathroom fittings described by Linn.

In an academic paper presented for her Post Graduate Course Ergonomics in 1980, Wilkinson outlined the requirements for an adjustable-height baby change-table. This included ascertaining the dimensions and attributes of six change-tables and also assessing the pressure upon the lumbosacral joint when changing a nappy and putting a singlet on a baby when on a bed and on a change table. The highest value was in standing and leaning over the bed while putting on the singlet with the baby in lying (192.6 kg). The lowest value for back loading was putting on the singlet with the baby in sitting, with the mother at a change table 12 cm. below elbow height (67.3 kg). As for suggesting a table height, the author quotes, amongst others, Ward and Kirk (1968) as recommending a bench height in the English kitchen, suitable for light to heavy work, to be between 77.06 and 99.89 cm. (as quoted by Wilkinson, 1980). The change tables measured by Wilkinson were between 74 and 82 cm., certainly at the low end of Ward and Kirk's range and at the end of the range more suitable for heavy work: Wilkinson therefore recommended the use of an adjustable change-table and also designed one.

3. METHODOLOGY

The lifting patterns of mothers could fulfill all four criteria which Chaffin and Andersson (1984) cite from the Work Practices Guide for Manual Lifting (NIOSH) as being factors that significantly increase the incidence of, and severity of, musculo-skeletal injuries. These criteria are that

1 the object is bulky ie when the horizontal distance (the distance from a point on the floor midway between the ankles to the location of the centre of mass of the object) is large,

2 the object is lifted from the floor,

3 the objects are frequently lifted.

4 the object is heavy.

The NIOSH Guide (1983) also outlined four criteria - epidemiological, psychophysical, biomechanical and physiological - for assessing the hazard level of lifting and said that they operate interactively. The four criteria, though, could be assessed independently.

Determining the cardiovascular/metabolic rates may have been an appropriate method for measuring the mother's workload. Chaffin and Andersson (1984) say that for "frequent lifting for an entire day" (an eight hour day) the metabolic load is the limiting factor and should be analysed. However, this would be a poor indicator of the metabolic load associated with the lifting of children as the mothers were not just mothering but also performing other "non-mother" tasks during their working day which would affect the readings.

The psychophysical levels for workload, as determined by Snook (1978), are appropriate when "moderate size or lighter weight objects are lifted *frequently, but for less than a one-hour period*" (Chaffin and

Andersson, 1984, p.268). The psychophysical approach is therefore not applicable to the workload of mothers with young children.

It was decided that, in an attempt to rank the physical workload of mothering, the L5/S1 joint would be used as the basis of the biomechanical analysis, since large proportions of the population suffer from pain originating in the lumbar spine at some stage of life (Troup, 1985). Loading on the low back has been analysed in many studies and a comparison with an occupation could therefore be made. Also, some guidelines pertaining to the physical demands of the job, for example, NIOSH, have been partially based upon the loading of the L5/S1 joint thereby giving a standard against which to rank different tasks.

A comparative task of nurses lifting patients was chosen, as nursing is a predominately female occupation and lifting is commonly cited as one of the tasks contributing to the occurence of low-back injury (Khalil et al, 1987, Gagnon, M. and Lortie, M., 1987).

However, as it was not expected that each individual task involved in the manual handling of children would in itself reach high compression levels and therefore be considered potentially dangerous, the cumulative workload over years of exposure were tentatively assessed. This was a comparison between the two groups (nurses and mothers) using the frequency of lifts and the L5/S1 loading levels. This index - frequency by L5/S1 disc pressure - was given the term "F x Pr" (Frequency x Pressure). A baseline exposure rate was established by multiplying the nursing aide's daily number of lifts by the average pressure in the L5/S1 disc during lifting and, assuming it to be a constant daily level, extrapolating it first to a weekly and then to an 8 years long exposure level. This long exposure time - 8 years - encompasses the manual handling time frame for three children: assuming there is 2 years between them, it covers from when the first child is 6 months to when, 8 years later, the youngest is 4.5 years.

The compressive loading on the L5/S1 joint of nursing aides when lifting patients was obtained from 2 studies carried out by Gagnon et al (1988) and Gagnon and Lortie (1987). They derived their calculations from the biomechanical model developed by Gagnon et al (1986).

The Michigan Three Dimensional Static Strength Prediction Programme (3DSSPP) was used as the biomechanical model to determine the loading of the mothers' L5/S1 disc when performing various lifts. It was chosen as it encompasses in its calculations the rotation of the spine and it is a convenient and straightforward system giving L5/S1 disc compression which can be measured against the NIOSH Guide. This model was developed at The Centre for Ergonomics, The University of Michigan.

A comparison of the two biomechanical models - Gagnon's and the 3DSSPP - shows that they are built upon the same principles although the Michigan model is more detailed as it is a three-dimensional model and includes the pressure from the abdominal muscle group. The effect of including the abdominal muscle group is hard to evaluate: Chaffin and Andersson (1984), state that in an experiment to validate the 10-muscle model developed by Schultz (1982), the correlation between the obtained EMG amplitude level and the predicted muscle force for the M. rectus abdominus and the Ms. abdominus oblique were only 0.5 and 0.2 respectively. The effect of the abdominal muscles, and their subsequent inclusion in any models therefore, still needs to be "carefully considered" (Chaffin, 1988).

Both models do have the limitation of being applicable only for static or quasi-static posture where the effects of acceleration and momentum should be negligible (University of Michigan, 1986, Gagnon et al 1986). The actual compressive forces on the disc during a real, dynamic lift, can be underestimated by up to 40% (Marras et al, 1986), or between 30 and 50 % (Mital and Kromodihardjo, 1986). In this paper, though, this error is constant in both groups.

As a control, eight of the lifting and lowering tasks of the mothers lifting the 2.5 year old only, were analysed according to the NIOSH Work Practices Guide For Manual Lifting using the Action Limit Formula (NIOSH, 1983). All eight tasks performed by one mother only were also considered to give a cumulative value.

To first get some measure of the frequency and type of lifting done by mothers, a questionnaire was devised by the author and given to the mothers of a total of 12 children, of 4 different age groups: 7-8 months, 2.5 years, 4.5 years and 6.5 years. There were 3 children in each group and the 2.5 year olds had to still be wearing nappies. The women were chosen as they had an appropriately aged child, did the majority

of the caretaking of the child (children) and spent at least several full days a week doing this. It was based around a typical 24 hour day and respondents were asked to itemize all lifts and carrying done throughout the day.

The frequency of lifts performed by the nursing aides was not itemised in the articles by Gagnon et al (1988) and Gagnon and Lortie (1987). The author therefore based the figure of 47 lifts per day upon worksite analysis of a private nursing home in Melbourne. This concurs with the author's clinical experience.

Three mothers were asked to participate in a laboratory simulation of the 5 most commonly performed lifting tasks as dertermined from the questionnaire. The heights of the women were 175 cm, 171 cm and 153 cm. The children lifted were aged 7 months, 2.5 years and 4.5 years. Six and a half year olds were not measured as it was determined from the questionaire that they were seldom lifted or carried. It was decided not to use mothers with children less than 6 months as the prevalence of the hormone relaxin could affect the reliability of the 3DSSPP readings. The 2.5 year olds had to still be wearing nappies.

The tasks performed were

1 lifting the child from the floor,

2 holding the child in a carrying pose,

3 lowering the child from the carrying pose onto the floor,

4 lifting the child into and out of a child car seat in a mock-up car backseat,

5 lifting the child into and out of a highchair, and

6 lifting the child into and out of a mock-up cot.

The last three tasks - lift into and out of the cot, highchair and carseat - were not performed on the oldest child.

Each woman was filmed simultaneously from three angles - anterior, lateral and superior - by video camera, and were given no instructions as to how to perform the task except that they perform each task once, and within the space needed to film them.

One point of each task was chosen to be analysed; this was when the trunk was estimated to be in the most flexed/rotated/laterally-flexed posture. The film was paused at this point, the relevant joint angles measured and the data entered onto the 3D programme to ascertain the loading levels on the L5/S1 joint for that posture: the loading for the 5th, 50th and 90th %ile females by stature were noted. Pictures of the postures analysed are provided in Appendix 2.

The 50th %ile levels from the three mothers for the same task were then averaged to give a single L5/S1 loading value for that task. This average disc compression per task was then multiplied by the determined daily frequency for that task to give the daily F x Pr value. The daily F x Pr values were added to give the daily F x Pr level per child and later multiplied by 7 to give the weekly value.

4. RESULTS

4.1 Nurses

The task of pulling/turning patients in bed is one that has been cited as an action frequently being performed when an injury takes place (Gagnon and Lortie, 1987). They analysed the action of pulling/turning a patient in five different ways varying the direction of pull, velocity of pull, position of the legs, placing the knee on the bed, height of the bed, or allowing the subject to choose the type of manoevre. Fifteen female subjects performed the manoeuvres and used a pique in all the actions. The resulting compressive forces in the nurses L5/S1 disc during the 5 tasks ranged from 2479 N to 3177 N.

In a study of six female subjects also performing a pulling/turning task on a patient, Gagnon et al (1988) analysed for the difference between a continuous movement and a movement interrupted by a pause

of approximately 1 second. They found the means of the compressive loads on the L5/S1 discs to be 2379 N and 2501 N for the two lifts analysed.

The average compression on the L5/S1 disc in the above-mentioned 7 tasks was 2771 N. As discussed previously, a nursing aide performs an estimated 47 lifts per day over a working week of 5 days; she therefore performs 235 lifts a week. Multiplying this by the average L5/S1 disc pressure gives an F x Pr of *651,185* which is the baseline used in this model.

4.2 Mothers

4.2.1 Interviews

From the interviews with the mothers, 25 different tasks were identified. These, with the average frequency per task per child, are listed in Table 1 below.

Table 1 Average Frequency of Lifts Over a 24 Hour Period

Type of Task	**Child**			
	6 mth	**2.5 yr**	**4.5 yr**	**6.5yr**
Cot - into	5	3		
Cot - out of	5	3		
To change nappy -				
onto change table	6	5		
from change table	6	5		
onto bed	8	4.5	1	
off bed	8			
Bath - into	1	1		
Bath - out of	1	1		
Highchair - into	3.5	3.5		
Highchair - out of	3.5	3.5		
Adult's Chair - onto	2	2		
Adult's Chair - off	2	2		
Floor - onto	9			
Floor - from	9			
Pram - into	1	2		
Pram - out of	1	2		
Child's Carseat - into	4	7		
Child's Carseat - out of	4	7		
Other Lifts -				
to below shoulder height	5	10	3	2
to above shoulder height	2	2	1	
Lower -				
from shoulder height	5	10	3	2
from above shoulder height	2	2	1	
Carry - <10 metres	2			
10-20 metres	2	2.5	1	
> 20 metres	5	4	1	
Total	**96**	**82**	**17**	**4**

"Other lifts" can include the mother lifting the child into her lap while she is seated, lifting onto a table or lifting from another person. The "Floor" lifts are as suggested, to and from the floor with perhaps some other activity in between.

Upon completion of the interview, each mother spontaneously commented that she felt sure that she had omitted several, if not many, lifts, suggesting that a more refined technique to gather the lift frequency data would generate a different result. Conclusions should only be drawn from the data with this in mind.

4.2.2 Experiment

Of the 25 identified tasks, lifting, holding, lowering and lifting into and out of car seat, cot and highchair were chosen for experimental recording, as these were the most frequently occuring tasks. The frequencies for the tasks relating to the car seat, cot and highchair were those given in Table 1; the frequencies for all the other identified tasks in Table 1 were grouped into the general term "lift" and "lower".

Three mothers of heights 153 (A), 171 (B) and 175 (C) cm, thus performed nine tasks on the two youngest children and three tasks on the oldest child; the oldest child was not lifted into the highchair, cot or car seat. This gave three L5/S1 disc pressure readings for each child and task performed.

To obtain the F x Pr values, the L5/S1 disc compression readings per child and task were multiplied by the relevant frequency.

Table 2a L5/S1 Disc Compression (in Newtons) per task, child and Frequency

Task	Age					
	7/12	Freq	2.5 yr	Freq	4.5 yr	Freq
lift	266	31	1133	26.5	1248	8
hold	881	9	926	6.5	1208	2
lower	186	31	980	22	595	7
car seat in	640	4	541	7		
car seat out	535	4	853	7		
cot in	399	5	1066	3		
cot out	533	5	972	3		
high chair in	339	3.5	348	3.5		
high chair out	279	3.5	1532	3.5		

Lifting the 2.5 year old in and out of the cot was performed by only two mothers due to shyness of the child.

Table 2b Frequency x Pressure value per task and child

Task	Age		
	7/12	2.5 yr	4.5 yr
lift	8246	30025	9984
hold	7929	6019	2416
lower	5766	21560	4165
car seat in	2560	3787	
car seat out	2140	5971	
cot in		1995	3198
cot out		2665	2916
high chair in	1187	1218	
high chair out	977	5362	
Total F x Pr	33,464	80,055.5	16,565

The weekly workload associated with lifting children for a mother of three over a period of 8.5 yrs can then be determined: the following table shows these results.

Table 3 Mother's cumulative workload over eight years based on average weekly Frequency x Pressure

Time Interval	Age of Children	Weekly Freq/Press.
7 mths	7 mths	234,248
2.5 yrs	7 mths, 2.5 yrs	794,356
4.5 yrs	7 mths, 2.5 yrs, 4.5 yrs	910,591
6.5 yrs	2.5 yrs, 4.5 yrs	676,343
8.5 yrs	4.5 yrs	115,955

Comparing the load levels over these time intervals against the baseline of the nurses reckoned average weekly Frequency/Pressure of *651,185* implies that a mother of three is exposed to considerably higher cumulative load levels over a substantial period of the early child-rearing years.

The results from using the NIOSH formula are given in Table 4. As all three mothers divided the "highchair out" lift into two stages with the child momentarily resting his feet on the seat, so the lift was analysed as two separate lifts, these being termed part 1) from sitting to standing on the highchair and part 2) from standing on the chair to standing on the floor.
The 2.5 year old weighed 16 kg. In only three tasks was the Action Limit value (ie. the maximum acceptable load) for all the three mothers above the child's weight: these were the tasks "lower", "car seat in" and "cot in". The two tasks "lift" and "highchair, part 2" had one value over and two values under the action limit. In the remaining four tasks - "car seat out", "cot out", "highchair in" and "highchair out part 1" the child's weight was greater than the action limit. The "car seat out" task had the lowest Action Limit, with a range of 8.8 to 10.4 kg. for the three mothers.

Table 4 Adapted Physical Stress Job Analysis (the load being a 2.5 yr old child weighing 16 kg) to establish the *Action Limits* of eight of the tasks in the study

		Hand location					
		Orig.		Dest.		Task	Action
Task	Mother	Hor	Ver	Hor	Ver	freq*	limit (kg.)
Lift							
	A	50	60	15	110	26.5	10.1
	B	43.2	67.2	15	100.8	26.5	12.5
	C	30	73.5	15	117.6	26.5	17.2
Lower							
	A	15	110	40	60	22	34
	B	15	100.8	43.2	52.8	22	30.6
	C	15	117.6	35	58.8	22	32.8
Car seat in							
	A	30	50.1	40	85	7	18.2
	B	35	57.5	50	80	7	16.8
	C	30	71	48	95	7	19.8
Car seat out							
	A	67.5	87.5	25	64	7	8.8
	B	60	90	30	65	7	10
	C	56	72	50	87	7	10.4
Cot in							
	A	15	98.5	55	67.5	3	37.6
	B	15	117	45	62.5	3	33.6
	C	--	--	--	--	--	--
Cot out							
	A	38	72	57.5	117.5	3	13.4
	B	45	65	15	117	3	11.1
	C	--	--	--	--	--	--
High chair in							
	A	44	74	64	83	3.5	13.5
	B	32	75	30	155	3.5	14.5
	C	39	57	30	77	3.5	15.2
High chair out - part 1							
	A	39	83	39	123	3.5	13.4
	B	50	90	15	125	3.5	10.9
	C	39	77	30	108	3.5	14.2
High chair out - part 2							
	A	39	127	22	69	3.5	12.5
	B	50	147	15	120	3.5	11.6
	C	26	99	19	60	3.5	20.3

5. DISCUSSION

The lifting/turning task of the nurses was reported as possibly being one of the precipitating factors in low-back injuries amongst nurses (Gagnon and Lortie, 1987). Therefore it was chosen as a comparitive measure for the study. But of course, nurses perform many other manual handling tasks with patients: helping them on and off the toilet, helping them dress, etc. The variety of lifting and transfer techniques used is many, dependent upon the type of patient, hospital (acute or long-term etc) and the work practises of the hospital. Obtaining studies of evaluation of the L5/S1 disc pressure for a wide variety of a typical nurse's daily tasks was seen to be unnecessary for this study. However, it probably would have given a better indication of the loading on this disc. The lifting/turning task was taken as an average.

The frequency of lifts was based upon all the techniques used, not just the lift/turn manoeuvre. Again a more accurate representation of the nurses workload could be made by better describing their duties.

In the raw data of the interviews with the mothers, there were large variations seen between the different individuals with respect to the number and types of lift done. The type of lift was affected by several factors. One was the equipment available, either through choice or necessity: 3 of the mothers used

their bed to change the child's nappy, (two of these women bent over to perform the task and the third knelt), while two other mothers used a change table and the last mother used a variety of different surfaces e.g. the floor, kitchen table or bed. The surface used determines the height and horizontal distance of the lift and therefore influences the difficulty of the lift.

Another factor affecting type of lift was the age of the child: the older the child, the more their physical capabilities, for example, they could climb off the bed instead of being lifted. Another was lifestyle: one 7 mth child was lifted from one spot on the floor to another because he crawled into corners and towards danger, while another of the 7 mth babes was rarely on the floor as her many siblings liked holding her. This also meant that her mother lifted her many a time from the sibling and these lifts fell under "other".

Whether the frequency of lifts was affected by the number of children the mother had could not be ascertained by the small sample interviewed. The difference between the 7 month old and 2.5 year old was not so large (96 to 82 lifts per day) and after 2.5 yrs, the frequency of lifts per task dropped substantially.

Taken each task in the experiment per se, there were no particularly high levels of L5/S1 disc compression; the highest was 2094 N when the 4.5 year old was being held, with the average for all lifts being 832 N. These levels are well below the *Action Limit* of 3400 N as given in the N.I.O.S.H. guidelines which suggests nominal risk to the person (Chaffin and Andersson, 1984). The L5/S1 disc pressure ranges between 0 and just over 2000 N and the differences did not correlate with either the child's size or mothers height. However, there was some variety between the mothers performing the same task; lifting technique appeared to be an important factor.

However, the applicability of these guidelines to the lifting tasks studied is limited as some of the assumptions are not met. These include: the lift was not symmetric (with respect to hand position), it was not in the saggital plane, the lifting posture was not unrestricted, the lift was not necessarily smooth and the load was sometimes moving thereby decreasing the quality of the coupling (Chaffin and Andersson,1984).

Another limitation is that the activities analysed did not make up the majority of the mothers' daily duties and that not all activities of either the mother or the nurse were evaluated, thereby violating one of the constraints of the applicability of the N.I.O.S.H. Guidelines (Garg, 1991). Tasks, and the corresponding disc pressures, that occurred between the measured tasks were not taken into consideration when evaluating the daily workload. This would perhaps have influenced the mothers values more than the nurses as not all the manual handling tasks of the children were measured, while the total number of patient lifts by nurses had been reckoned as 47 per day; both groups would have been doing a variety of other duties.

The comparison between the mothers of 3 children and the nurses, as devised by the author, also suggests quite a difference in the mothers workload over time. The mother's load peaked at 910,591, which is approximately 20% higher than the estimated baseline of the nurses. This indicates that, compared with nurses, the cumulative effect, on the L5/S1 disc, of the manual handling of children by mothers is substantial, especially during the years of caring for 3 toddlers.

A comparison of the F x Pr levels between the 7 mth child and the 2.5 yr child for the lifting task showed a considerable increase: 8,246 to 30,024 (see Table 2). This also occured with the lowering task, the increase being from 5,766 to 21,560. As the frequency was actually higher with the younger child, the increased F x Pr measurement is due to the effect of the extra loading. If a suggestion by Garg (1991) is considered - that one aspect contributing to back injury is the local muscle fatigue caused by the holding, moving and carrying of the body itself - then the heavier weight of the older child will add to this effect (as would lifting and carrying any heavy object).

One large increase in the F x Pr levels was for the task of "highchair out", where the level for the 2.5 yr old was 5 times that of the 7 mth old. The frequencies were the same but the L5/S1 loadings were quite dissimilar. Technique, especially distance of the load from the lifter's centre of gravity, combined with the extra weight, may be the important contributing factors here.

There are of course limitations with the measurement of F x Pr level. One is that the model assumes a linear relationship between the intervertebral disc pressure and the risk of developing a back injury. Another is that it assumes the effect of one lift can be added to the effect of the next lift and so on, and it

does not take into account the pauses allowing for rest between each lift when the intradiscal pressure could return to its normal level. Whether this happens is dependent upon the mother returning to the upright position without a load and this may well not be the case. Nor does it allow for the effect of the duration of the lift.

The extrapolation of the data gained from this experiment over time assumes a constancy of manual handling techniques over the 8 year time period: this may or may not be the case with either the nurses or the mothers.

The F x Pr level is based upon a 52 week year; while the nurse may have a 4 weeks annual holiday, few mothers would have this length of holiday free of their children, though they would probably receive more help from their spouse during this time, as they hopefully would at the weekends.

The *Action Limit* results indicated that the manual handling of the 2.5 year old was often stressful for the mother. This was suggested by both the combined task and many of the individual task values. The factor contributing most to the low *Action Limit* values was the horizontal factor, indicating that these lifts were performed away from the body. However, the NIOSH Guide is of limited value when evaluating lifting living, moving, fighting loads at angles not covered in the Guide.

Recommendations from the experiment would have to be based upon the ideas about manual handling principles expressed in the current literature. As mentioned earlier, this includes such things as weight of object and distance to be lifted. Garg (1991), maintained that free style lifting is actually better than the "straight back/bent knees" method and that the most important factor to control for in the lift is the horizontal distance between the person's back and the object. Examples of situations involving these principles but not evaluated in the study would be: placing or lifting the child onto a bed or change table, into and out of the middle back seat in the car, lifting a pram into and out of the car, and carrying and lifting full nappy buckets.

In this study, the car seat was by the door and the mother could get as close to the cot and highchair as she wished. The experimental lifts could have been chosen with the more extreme positions in mind: however, they were chosen according to the data obtained from the questionnaire.

One aspect of preventing low back problems, whether working with children or doing other tasks, is having suitably designed equipment, for example, the static posture of and loading on the back when standing, sometimes bent over, at the change table suggests it should be at a height appropriate to the user. Wilkinson (1980) designed an adjustable change-table, but there are none on the market in Victoria. The equipment associated with this study - highchair, cot and carseat - were not associated with high levels of lumbar disc loading per se and as such cannot be unduly criticised. Lifting out of the Baby Safety Capsule with the child in place was not analysed, and yet it is an action that is often performed, although not recommended by the manufacturers of the Capsule (Everett, 1986).

Patterns and techniques of manual handling, especially lifting and carrying, should be analysed and discussed through public education mediums either when the woman is still pregnant (although the efficiency of teaching such matters at this stage would need to be evaluated), through the Child and Maternal Welfare Centres or through other public health education programmes.

Specific suggestions for women working in Child Care Centres or hospitals etc, regarding the manual handling of children and low back problems should be directed towards mothers with several toddlers, where the compounded frequency of manual handling tasks might indicate risks. An accurate analysis of their manual handling practices would need to be carried out to ascertain the frequency and types of tasks performed and to then evaluate them.

An interesting observation from analysing the results on the 3DSSP Programme was the low percentage of the female population with "sufficient strength capability" in the shoulder and elbow joints to perform some of the tasks. In the "car seat in and out" task, 11 of the 26 values obtained indicated that only 17% of the female population had sufficient strength to perform the tasks; in the "highchair in and out" task, 9 of the 24 values obtained indicated that less than 20% of the female population had sufficient strength to perform these tasks. This suggests that another valid area for research, regarding mothers and their manual handling of children, could be exposure to the shoulder and elbow region.

6. CONCLUSIONS

The hypothesis that the cumulative effect of the manual handling involved in the raising of three children could be a contributing factor in the development of low-back pain later in women's working life was supported by the material gained in this study. The cumulative workload, measured as L5/S1 disc pressure, was estimated to be, at its peak, more than 20% higher than that of nurses' estimated workload measured similarly. This indicates that the low-back could be an injury risk area for mothers, especially with regard to the manual handling of several children simultaneously. It was also suggested when analysing the results, that the shoulder and elbow regions may be valid areas in which to assess the physical demands of some of these manual handling tasks.

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