Anthropometric Variability, Equipment Usability and Musculoskeletal Pain in a Group of Nurses in the Western Cape

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DECLARATION

I, Winifred Edna Botha, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other University.

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Abstract

This study examined the anthropometry and anthropometric fit of a group of ward and theatre nurses in Western Cape private hospitals. Anthropometric variables were measured using a sample of nurses and a correlation matrix generated. All nurses were given a questionnaire concerned with operational problems in the work environment and musculoskeletal pain. The questionnaire was also completed by a group of sedentary nurses.

The ward and theatre nurses reported numerous problems in the working environment, including lumbar backache, inadequate space and equipment that caused bodily discomfort. There were consistent, statistically significant associations between the frequency of occurrence of these problems and the anthropometric data indicating that the problems were caused or amplified by body size variability and were not simply general usability problems which would affect all nurses irrespective of their body dimensions. Further studies testing specifically for the consequences of mismatches and body size variability are recommended.

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The nurse must be able to get easily to both sides of the bed, and to reach easily part of the patient without stretching............ a thing impossible if the bed be too wide or too high (Florence Nightingale, 1859, quoted in Pheasant, 1987).

1. Introduction

When designing objects and environments for human use, the dimensions and characteristics of the users should be properly considered. There should be a comfortable, safe and satisfactory match between the artefact and the user. The aim of user-centred design is to identify the potential physical mismatches between users and products, environments, clothing, equipment, workstations and furniture. To achieve this match, it is necessary to identify the characteristics of the user population, and to take the physical dimensions into account. It is well known that there is a high prevalence of musculo-skeletal pain in the nursing profession (Pheasant, 1987, Cust et al., 1972, Stubbs et al., 1983a, Skovron et al., 1987, Dehlin et al., 1976, Magora, 1970 and Hignett, 1996a,b).

This project was undertaken because no data are available on the anthropometry of members of the South African nursing profession. This is particularly relevant to South Africa, as we have such a heterogeneous population. There is increasing urbanisation amongst women, where they traditionally would stay at home in the rural areas to raise their families, while the men worked in the industrialised cities and mines. One of the aims of this project is to measure anthropometric variability. An assessment can then be made to see if this variability causes problems in the working life of nurses. Where problem areas are identified, recommendations will be made. There is an urgent need for studies of this nature, as is illustrated by research conducted in various other countries. This project aims to establish whether body size variability is taken into account when designing work spaces and equipment and how it impacts on the use of these.

Anthropometry is the practice of measuring the human body. The word originates from the Greek language, *anthropos* meaning man, and *metron* meaning measure. Anthropometric measurements are needed by ergonomists and designers to specify correct dimensions for the design of clothing, workspaces and equipment e.g. beds, dripstands, operating tables, cupboards and shelving. This would also include the space around the equipment. This information is specifically needed to avoid potential mismatches between the design and the usage of the products.

Recommendations can then be made for adaptations to improve the design, the work station and the working environment, as well as alternative ways of performing an existing task. Making these changes would help to relieve postural stress and prevent work-related injuries. This would also lessen absenteeism due to sick-leave, as well as minimising staff losses due to injuries. Musculoskeletal problems account for 30% of work time lost due to sickness absence (Westgaard and Aarås, 1984). In their follow-up study in the same project, Westgaard and Aarås (1985) found a vast reduction in both long term sick leave as well as in staff turnover after ergonomic improvements were implemented in a factory. Parenmark et al. (1988) found that less musculo-skeletal complaints were suffered by a group of new workers who received ergonomic training and posture correction in the work place. Manuaba et al. (1989) found that nurses worked more efficiently and effectively in a hospital where ergonomic principles were applied.

1.1. Criteria and Constraints of Design

For a design to be ergonomically sound in terms of anthropometric fit, it needs to accommodate 90 % of the potential user population, which is defined as the range between the 5th and 95th percentiles on a normal or Gaussian distribution of the measurements.

There are therefore certain criteria and constraints that need to be satisfied. A constraint is a measurable anthropometric characteristic of the user, which falls in the 90% user population, such as stature, e.g. the height of a door should accommodate as wide a range of people as possible. Selection of door height is therefore constrained by stature. A criterion is defined as how well the object and the user are matched. This is assessed in terms of safety, comfort and efficiency, which are regarded as higher level criteria, while lower level criteria also need to be satisfied. This can be illustrated in an example of the desirable height of a fixed height desktop. If the desk is too low, the pressure on the top of the thighs will cause discomfort to a user with a large thigh thickness. Therefore a fixed height desk should be designed to be high enough to accommodate the widest range of people in the user population.

Pheasant (1986) identifies 4 cardinal constraints of anthropometry in ergonomics:

1.1.1. Clearance

Workstations should be designed to allow adequate headroom, legroom and elbow room, clearance for the hands, and also handles that allow sufficient space to be comfortably grasped. Adequate access and circulation space should be provided.

1.1.2. Reach

This is concerned with the location of controls and the design of storage space, thus enabling the user to reach and operate controls, as well as to perform a task without having to reach over an obstacle of any kind. The area within an arm's length, where the straight arm can move freely in all directions, can be used to describe the "reach envelopes". These are zones of easy or maximum comfortable reach around an operator.

1.1.3. Posture

The posture that a worker adopts is determined by the relationship between the body dimensions of the worker and the physical dimensions of the workspace, as well as the task that needs to be performed. In design, care should be taken to avoid postural stress, which is caused by prolonged static muscle loading. Static postures, asymmetrical positions, prolonged forward inclination of the head and trunk should be avoided, as well as postures that require a joint, such as the wrist, to be held at the end limit of range of movement. In seated tasks, adequate back support should be provided. Regular change in working posture is recommended.

1.1.4. Strength

This constraint is concerned with the muscular exertion needed to perform tasks, manipulate and operate controls.

The anthropometric factors which should be taken into account, in the design of products, equipment and/or the environment, are clearance, reach, posture and strength requirements (Pheasant, 1986), as described above. In a study of the anthropometric aspects of a workstation design, Pheasant (1987) examined the design of hospital equipment, hospital beds and lifting strength. Nurses spend a vast period of time in the stooped position - either bending over a too-low work surface, or reaching forward over obstacles. This can lead to postural stress that is associated with deficiencies in the workstation design. Various tasks are to be performed at the hospital bed, such as the lifting and handling of patients, changing dressings, and inserting catheters. All these tasks should be performed at different heights to minimise postural stress. This is extremely difficult when using a bed with a fixed height.

1.2. Types of Anthropometric Data:

1.2.1. Static (Structural) Data

These are measurements made from one clearly defined anatomical landmark to another, with the subject in the stationary position. Static anthropometric data are required and used by wholesale clothing manufacturers, and designers of furniture, vehicles and equipment.

1.2.2. Dynamic (Functional) Data

These are measurements of the range of movement of body parts. This is needed to design space and/or equipment so that it is well suited to the users and the requirements of their tasks, such as reach, and constraints such as clearance.

To ensure optimal usability in design, the following information is needed:

- The anthropometric characteristics of the user population.
- The ways in which these characteristics might impose constraints on design.
- The criteria which define an effective match between the product and the user.

In this study only static data were measured, to acquire a basic database of nurses' anthropometry which can be used to investigate physical mismatches and their consequences.
Barkla (1961) and Pheasant (1982) developed a technique to estimate the physical dimensions and ranges of adjustability in the design of products. Even though tables of anthropometric variables are available for some populations, these are often incomplete and not up to date. In many instances, one can also not assume that the data of the target population is representative of the local population. To use this method, the stature measurement of the target population should be known. A set of scaling factors is then derived from a reference population and used to estimate the dimensions needed for the specific design.

1.3. Influences on Anthropometric Characteristics

There are various biological and social differences in groups of human beings that may influence their anthropometric characteristics. These are (i) *Gender differences* (i.e. male or female), (ii) *Ethnic differences* (i.e. behavioural distinctiveness such as beliefs, customs, dress, songs, language and arts),

(iii) *Race differences* (i.e. biological distinctiveness, which most modern researchers consider to be the effect of a shared gene pool. It can and does result in patterns of morphological distinctiveness), (iv) *Body type* (i.e. endomorph (overweight), mesomorph (muscular) or ectomorph (thin)), (v) *Growth and development* (i.e. the influence of, inter alia, diet, disease, disabilities and deformities), (vi) *The secular trend* (i.e. the changes in measurable characteristics amongst a population of people over a period of time, such as the increased growth rate of children and increased adult stature. Tanner (1962,1978) concludes from available evidence from most European countries, an approximate increase of 10 mm per decade in adult stature and a growth of 15 mm per decade in stature and 500 g per decade in weight at 5-7 years of age). (vii) *Age* (i.e. child, adolescent, adult or senior citizen) and (viii) *Social class and occupation.*

1.4 General Statement of Aims

Clearly, nursing is a profession of high postural stress. Very few studies exist on the anthropometric data of South African women. The present investigation sought to fulfil the following aims:

a. To generate a set of anthropometric tables of the nurses working in the Western Cape.
b. To establish the occurrence of occupationally-related musculoskeletal pain.
c. To establish equipment, workplace and general usability problems.
d. The hypothesis that pain and usability problems were related to body dimensions was tested.

1.5. Sources of human variability

The word 'Plasticity' has its origin in the family of Greek words with the root *plassu* and is defined as "the capability of being moulded". Lasker (1961) (cited in Roberts, 1995) used the word to refer to the "capacity of the individual to change in response to his environment" and qualified it as the "capacity to change within the lifetime of the individual. It applies especially to those permanent effects that may occur as a result of changed environment during the growth period". The mechanism for plasticity in human biology is found in those processes that regulate amount of growth and rate of development of all the segments of the body, such as body segments, organs, tissues and populations of cells. Adaptation is the change that takes place through interaction with the environment, particularly when these environments are stressful.

There are four levels of adaptation, namely: acclimatisation, plasticity, population structure and natural selection. All these different levels of adaptation take place on different timescales. Acclimatisation is the quickest process i.e. the immediate effect in the heart beat of a short distance runner. The timescale of plasticity is the total life-cycle of the individual human being. The changes of plasticity normally take place early in life, but may also be active in later years, such as permanent immunity to an infectious agent acquired at an older age (Boldsen, 1995). Population structure modification acts on an inter-generational scale. Changes of gene frequencies in large populations take place relatively slowly, usually over hundreds of years. Biological processes take place on all timescales. Information on all four aspects of adaptation is rarely found in the same set of data.

Early empirical studies showed that the immediate environment does affect the body form. It was shown in Europe that the heads of babies that are habitually placed in the supine position develop to be broader (where the weight of the head falls constantly on the occiput), than those babies that are more often placed on their sides (Walcher, 1905,1911 cited in Roberts, 1995).

Analysis of records of recruits in the northern armies during the civil war in the United States reveals that the American-born recruits were taller than the European-born (Gould, 1869 cited in Roberts, 1995).

There is also evidence of physiological adaptation at high altitude levels where large static lung and heart volumes relative to body size are developed. The large highland chests in Native Americans are acquired due to an accelerated development of the thorax relative to stature during childhood and particularly adolescence (Mueller et al.,1979 cited in Roberts, 1995). These changes do not only occur in children born at high altitudes, but also to those who move to these high lying areas at a young age. This large chest size of the high altitude people is retained when moving to sea level.

Birth weight has been reported by many researchers to be reduced at high altitude. Many of these studies lacked control of the maternal nutritional status. A study done by Hass et al. (1980) tested the hypothesis that altitude differences in foetal growth exist independently of maternal nutritional status, and that indigenous Amerindian (Quechua and Aymara) women deliver larger infants at high altitude than non-Indian women, who were born and raised and completed a full term pregnancy in the same altitude environment. Samples of 105 healthy mothers and infants from La Paz, Bolivia (3600 m) and 77 from Santa Cruz, Bolivia (400m) were analysed for altitude and ethnic variation. Analysis indicated significantly smaller infants were born at high altitude and to non-Indian women and that male infants were more affected by high altitude than female infants.

One of the biocultural features that characterise the present day Maya of Guatemala is short stature. The Mayans being 'genetically short' is sometimes attributed to generations of adaptation to poor health and a poor nutritional environment. A study done by Boas (1912), cited in Bogin (1995) on migrant Mayan refugees in the United States found that this "genetic shortness" is incorrect, as an improved health and nutritional environment lead to increased growth. This is due to a change in environment and not a biological adaptation. The children in this study were found to be taller, heavier, carrying more body fat and muscle mass than the Mayan children that live in Guatemala. The average child was, however, found to be shorter than children of the African-American, Mexican-American and European-American children living in the same town. It was concluded that the Mayan refugees in the United States are in the process of a secular trend in growth, and that given the same opportunities and access to health and socio-economic status, they should have an average stature similar to the general North American population in a few generations.

General consensus in research on the consequences of childhood under-nutrition is that it causes reduced adult body size, impaired work capacity throughout life, delays and permanent deficits in cognitive development and impaired school performance (Pelto & Pelto, 1989, cited in Bogin, 1995). Indicators of poor biological adaptation in the Guatemalan children of poor backgrounds and low socio-economic status is the high incidence of infectious diseases, infant and childhood mortality and cognitive delays and deficits. Reduced growth is not adaptive in any sense - height reflects health and nutritional history, and weight and body composition reflect more recent events. It is the environment for nutrition and health that brings about responses in growth, rather than any genetic changes. The major reason for secular trends in populations is the decrease in the levels of chronic under-nutrition and disease (Bogin, 1995). However, in a study by Henneberg and Van Den Berg (1990), no difference was found in the growth rate and development between advantaged and disadvantaged South Africans.

Results of a comparative study done in Denmark between measurements taken from graves at two mediaeval cemeteries and young men prior to conscription showed that the mean male stature had increased by some 1300 mm over the intervening years (Boldsen, 1995). From the analysis it was concluded that the population structure effect ("outbreeding" or heterosis) on stature was 590 mm (45%) and the plasticity effect 720 mm (55%). The purpose of this study was to isolate the effects of the adaptation processes on the Danish population. Two processes were identified, namely, the improvement of conditions of living which led to the greater realisation of the growth potential of the population, and breaking down the traditional pattern of spouse selection (heterosis). It is expected that the breaking down of reproductive isolation in local communities would have an immediate effect on the mean stature.

1.6. Anthropometry, Variability and General Design

Abeysekera and Shahnavaz (1989) compared variations in body size between workers in industrialised countries (IC), and those in industrially developing countries (IDC). Today IDC's depend largely on their supply of industrial goods from IC's. In IDC's the unavailability of reliable anthropometric data, as well as the unawareness of the importance of ergonomic principles related to the design of goods, contribute to the mismatches that take place between the users and the imported products. A product designed according to correct ergonomic principles should be able to satisfy the requirements of 90% of the potential user population. The authors concluded that goods that accommodate 90% of users in IC's, were only physically compatible to 57% of South African users and as low as 13% of Vietnamese users. Manufactures, buyers, administrators, planners and designers should be made aware of the anthropometric requirements of users when dealing with imported goods. The authors also called for more anthropometric studies similar to this one, especially in industrially developing countries.

Marras and Kim (1993) conducted an anthropometric survey on an industrial population (384 males and 124 females) from various manufacturing industries in the mid-western part of the United States. These data were compared to other civilian and military anthropometric data. Significant differences existed between these populations in abdominal dimensions and weight. The differences were more pronounced in the male population than the female population. Variability of abdominal dimensions and weight were also greater in the male population than the female population. The differences were also observed to vary with age. The authors concluded that the anthropometric data should be useful for designing new or improved industrial workplaces and equipment.

In a study of truck cab design in relation to the anthropometry of truck drivers, Miller and Straker (1991) looked at mismatches between bakery delivery truck cabs and drivers. The anthropometric measurements of 46 men and 6 women were taken. Based on this information, mannequins were constructed to scale. The cab features were measured and diagrams drawn to scale. By superimposing the mannequins on the diagrams, reach and clearance mismatches could be identified. In the Ford Trader cab results showed that while maintaining lumbar support, problems were experienced in reaching the accelerator pedal by the females up to the 50th percentile, and males at and below the 5th percentile. Additionally, the 5th percentile males could not reach the brake pedal and the 5th percentile females had to lean forward to put the gear lever into first position. Minimal head clearance was experienced by the 85th percentile males. Both males and females of the 95th percentile had inadequate thigh support. The males also experienced difficulty in the thigh clearance of the hand brake and the steering wheel. The authors concluded that the study data should provide useful information for the future design and purchase of trucks. The authors did not make it clear specifically which variables caused the constraints.

Haslegrave (1979) conducted an anthropometric survey on British drivers and concluded that in the design of motor vehicles, or any other equipment, the range of interest is between the 5th percentile female user and the 95th percentile male user. The study further concluded that the mean stature value and the 5th percentile stature value of British female drivers were higher than their American counterparts by 25 mm and 38 mm respectively. At that time American statistics were used for design in the United Kingdom. This study only collected data on the British driving population and compared it with that of their American counterparts.

A questionnaire study and a field study of the TH-57 Jetranger helicopter were conducted from an anthropometric standpoint by Chapleski and Adrian (1990). Anthropometric measurements of the United States Navy student aviators as well as all the measurements of the cockpit were analysed. The main problems identified in the cramped cockpit environment involved safety factors, such as obstructed visibility and difficulties in reaching and even seeing some instruments and gauges, comfort factors such as lack of seat adjustability, and a sub-standard climate control system. A total redesign led to the hypothetical development of a TH-57D, where several recommendations took into account the safety and comfort issues discussed. The authors concluded that the method of using questionnaires is the only avenue to ensure good communication between the designer and the user of the aircraft. The recommendations should ensure the most efficient as well as the safest man / machine interface.

Buckle et al. (1990) conducted a study to determine the critical clearance and reach requirements for the satisfactory operation of flight deck equipment of aircraft. These data were used to propose anthropometric selection criteria for trainee pilot recruitment. The measurements of reach and clearance were taken from 4 training, full flight simulators having exact replicas of the different flight decks for the aircraft that made up an airline fleet. The measurements taken included seated eye height, buttock-knee length, forward grip reach, overhead reach buttock-heel length, thigh clearance, abdominal depth and the minimum hand widths. The anthropometric data collected showed that an increase in the available selection pool could be effected if further considerations were given to functional dimensions during the design process. The current selection criteria, based on functional seated eye height, may exclude 73% of the British female population and 13% of the male population.

In a study done by Kayis and Ozok (1991), anthropometric measurements were taken of 5109 Turkish Army men, aged 18 -26 years, who came from various geographical areas in Turkey. The investigation was done due to its importance in the design of workplaces and equipment. The authors concluded that the anthropometric variables of Turkish Army men indicated significant differences compared with other data in other publications. Work spaces and equipment should be designed with the anthropometric characteristics of the user population in mind.

Wisner (1989) concluded in a study concerning the variety of the physical characteristics in industrially developing countries that anthropometric features of people are not unchangeable. He found that the part played by genetic factors was not isolated and socio-economic conditions and changes may have a considerable effect on physical measurements of the world's populations. The dynamics of these evolutions is of considerable interest to ergonomists who are interested in improving technology transfers. Similarly, in South Africa, it is expected that with improved living conditions and healthcare, plastic changes will now be occurring in previously disadvantaged communities.

1.7. Ergonomic Design and Musculoskeletal Pain

Musculoskeletal pain has been the subject of much research and several review articles in recent years, particularly related to the work place. It has become very problematic in industrialised countries (Kuorinka and Forcier, 1995). Musculoskeletal problems account for 30% of work time lost due to sickness absence (Westgaard and Aarås, 1984). Awkward postures and excessive muscular load and force contribute to these complaints.

Kuorinka and Forcier (1995) define a risk factor as: "An aspect of personal behaviour or lifestyle, an environmental exposure (including work) or an inborn or inherited characteristic, which on the basis of epidemiologic evidence is known to be associated with health-related conditions considered important to prevent. The term 'risk factor' is rather loosely used, with any of the following meanings:

- An attribute or exposure that is associated with an increased probability of a specified outcome, such as the occurrence of a disease. It is not necessarily a causal factor, but a risk marker.
- An attribute or exposure that increases the probability of occurrence of disease or other specified outcome, in other words, a determinant.
- A determinant that can be modified by intervention, thereby reducing the probability of occurrence of disease or other specified outcomes. To avoid confusion, it may be referred to as a modifiable risk factor. "

1.7.1. Musculoskeletal Risk Factors of the Upper Limb, Shoulder and Neck

Kuorinka and Forcier (1995) compiled a summary of research on work-related risk factors for the following conditions:

Conditions of the Neck

- Heavy lifting, monotonous work and uncomfortable posture (Swedish employees undergoing routine screening examinations).
- Static load and awkward neck/arm working positions (e.g. metal industry workers).

Shoulder Conditions

- Working with the hand at or above shoulder level in extreme working postures (e.g. shipyard welders and - plate workers).
- Forceful and repetitive work with the hands and wrists (e.g. industrial workers).
- Repetitive flexion movements of the shoulder (e.g. industrial workers).
- Repetitive arm work where extreme working positions of the arms and hands, and static shoulder muscle work, were present (e.g. assembly line packers).

Lateral Epicondylitis

- Strenuous tasks involving the muscles and tendons of the arm (e.g. sausage makers, meat cutters and packers).
- Overuse and strain of the flexor and extensor musculature of the wrist and hand (e.g. meat cutters).
- Highly repetitive and strenuous work involving the muscles and tendons of the arm (e.g. meat cutter and sausage makers).
- Repetitive arm work, including extreme and static working postures (e.g. assembly line packers).

Conditions of the hand and wrist

- Work tasks that cause strain to the muscles and tendons of the arm (e.g. meat cutters, assembly line packers, sausage makers).
- Repetitive and forceful tasks involving the hands (e.g. industrial workers).
- Work that requires repetitive arm movement (e.g. assembly line packers).
- Repetitive and forceful grasping with the fingers spread open (e.g. industrial scissors makers).

However, not all researchers agree on the work-relatedness of these musculoskeletal conditions. In a review article Barton et al. (1992) concluded that no sound evidence existed to attribute disorders of the neck, shoulder or elbow to occupational activities. The authors concluded that the only musculoskeletal disorders that should be included in occupational conditions, should be inflammatory conditions of the tendons in the hand and forearm and cramping in the hand and forearm.

In a survey of dentists, Rundcrantz et al. (1990) reported an association between the use of a mirror to gain a direct view of a patient's mouth and less reports of discomfort. 72% of dentists reported pain and discomfort from headaches, the neck or the shoulders. The study did not identify specific working postures and positions which could possibly have contributed to the musculoskeletal pain and discomfort.

A comparative study of neck and shoulder pain between sewing machine operators and a control population revealed a relationship between working conditions (mainly in constrained postures and short cycle movements) and neck and shoulder complaints in the sewing machine operators (Blåder et al., 1987).

Several researchers examined the prevalence of upper limb pain and discomfort in supermarket checkout workers. Harber et al. (1992) reported that length of working hours as well as years on the job significantly contributed to upper limb pain in supermarket scanning personnel. Baron et al. (1991) found that the relative risk of shoulder pain was higher in supermarket checkers than in other employees in the retail trade. Scanning and number of hours worked, compared to cash register operation were identified as risk factors for shoulder pain in these workers.

Kuorinka and Koskinen (1979) found that scissors makers have a higher risk for developing hand or wrist tendonitis than shop assistants in a department store. A higher risk was also reported for developing neck tension syndromes in the scissors makers.

Amano et al. (1988) compared assembly line workers in a shoe manufacturing plant to non-assembly line workers. A higher risk was reported in the assembly line workers for neck and shoulder pain. Repetitive movements were implicated as the risk factors. Parenmark et al. (1988) found that the number of sick leave days for neck and shoulder complaints were less in a group of new workers who had received ergonomic training, than in a control group with no ergonomic training. Not only the work stations were ergonomically designed, but the workers also received training in good working posture.

Turner and Buckle (1987) in their review of carpal tunnel syndrome, concluded that it might or might not be work-related as systemic conditions may be the cause in up to 30% of cases. In another review, Hagberg et al. (1992) concluded that occupational activities such as forceful grips and repetitive hand movements could be likely causes and risk factors for carpal tunnel syndrome. Vibration exposure was also associated as a risk factor for carpal tunnel syndrome.

In studies comparing specific job titles Herbets et al. (1981) reported a higher risk of rotator cuff tendonitis in shipyard welders compared to office workers. McCormack Jr et al. (1990) found that packaging and folding workers have a higher relative risk of developing hand or wrist tendonitis than knitting workers. Letter carriers with shoulder bags bearing down onto the shoulder, reported a higher prevalence of shoulder pain than meter readers and postal clerks (Wells et al., 1983).

A cross sectional study was conducted by Punnett et al. (1985) involving female employees in the garment industry and female employees in a hospital setting. The garment workers reported a significant higher prevalence of shoulder pain than the hospital workers.

In a study on working methods, Magnusson et al. (1987) found that high loads are imposed on the back and upper limbs of butchers. These loads are often imposed at the same time and were identified as exertion of high forces, heavy and frequent manual handling, and poor working postures. From the study it was concluded that better designed equipment and appropriate working heights should be introduced to reduce these large loads imposed on butchers.

Shoulder disorders are very common among industrial workers (Herberts et al., 1980). The load placed on the muscles of the shoulder is determined by the working height of the hand. Overhead work is therefore a considerable risk for developing shoulder pain. This is also confirmed by Kadefors et al. (1976), where elderly welders were found to commonly suffer from supraspinatus tendonitis. Wiker et al. (1989) also suggest that the hands should be positioned at waist height and close to the body when performing light assembly tasks in order to lower the postural loads on the shoulder girdle complex.

Blue collar workers take more sick leave for shoulder disorders than white collar workers (Kvarnstrom,1983). Given the nature of the job, blue collar workers are possibly not able to persist in their task, due to the pain and discomfort. More workers in a manufacturing plant considered their work heavy, associated with heavy lifting, compared with responses from white collar workers. Working positions in the manufacturing plant were considered unsuitable, monotonous and stressful. In their study, Bergenudd et al. (1988) found that sick leave absence occurred mostly in "heavy" and "moderate" demand work, and not in "light" demand work.

Roto and Kivi (1984) found a higher risk for lateral epicondylitis for meat cutters compared to construction foremen. Overstrain of the flexors and extensors of the wrist and fingers was implicated as the cause. However, in a study done by Viikari-Juntura et al. (1991) no difference in the prevalence of either medial or lateral epicondylitis amongst meat processing workers (meat cutters, sausage makers and packers) was found compared to unexposed workers such as supervisors, office- and maintenance workers.

1.7.2. Musculoskeletal Risk Factors of the Lower Back

Back pain does not only affect workers, but is prevalent in the general population. Nachemson (1976) reported that 60-80% of the general population experience back pain sometime during their lives.

Yu et al. (1984) described work place risk factors for lower back pain in industry as static working posture, lifting, bending, twisting, slipping and vibration. Evidence that individual factors were associated with back pain in industry was found to be inconclusive.

Riihimaki (1991) summarised evidence for the following possible risk factors: sedentary work which can cause stress in the lower back, which in turn can lead to pain. The author reports that positive associations were found in some studies, but that the evidence is still insufficient. Studies showing associations between whole body vibration and lower backache are also cited. Manual handling (lifting, pushing, carrying and pulling) is found to be a risk factor only if the tissue endurance is exceeded. Non-neutral trunk postures and psychological factors were also supported as risk factors for lower back pain.

Kelsey et al. (1990) described risk factors for lower back pain in general as well as for intervertebral disc prolapse specifically. The reviewers cited the following possible risk factors for low back pain: sedentary occupations, stationary postures for long periods of time, frequent stretching, reaching, pulling and pushing at work, lack of physical fitness, pregnancy, recent employment in a physically demanding occupation, occupations that require frequent twisting without having to lift objects, body height and psychological symptoms. The authors note that the evidence for the above was inconsistent or weak. As risk factors for intervertebral disc prolapse specifically, the following factors were identified: frequent lifting (especially objects that weigh 12 kilograms or more, and the arms forward, the body twisted and the knees straight), exposure to whole-body vibration (such as driving a motor vehicle), narrow lumbar intervertebral canals and cigarette smoking.

In a study in an automobile assembly plant Keyserling et al. (1988) reported associations between persistent lower back pain and working postures such as forward flexion, lateral flexion and twisting. Punnett et al. (1991) reported the same associations in a similar study in an automobile assembly plant.

Pheasant (1991) concluded that low back pain is predominantly a work-related condition. Although back pain is a commonly found condition, when dividing the population in categories according to occupational task requirements, the result is that in some occupational categories back pain is found more than ten times more than in other categories, and in others, back pain is very rare. Pheasant (1991) summarised the ergonomic risk factors as the following: prolonged sedentary work, prolonged work in a stooped position, heavy work (manual handling, forceful exertions, bending and twisting), vibration and psychological stress. Personal risk factors were summarised as strong risk factors (previous history of low back pain, low overall fitness, low lifting strength, low back muscle endurance, smoking and motherhood), moderate risk factors (hypermobility, spondylosis, spondylolisthesis, scoliosis and unequal leg length, weak trunk stabilizers), weak or very weak risk factors (stature and obesity) and factors of no predictive risk value (lordosis, abnormal number of vertebrae and spina bifida occulta). Pheasant (1991) concluded that the ergonomic risk factors are more significant than the personal risk factors when predicting low back pain.

Li (1992) and Mital et al. (1993) considered stature as a risk factor in manual handling tasks. Taller individuals have to reach and lean further when picking up or lowering a load, placing more compressive and shear forces on the intervertebral discs in the L5/S1 region of the lumbar spine. Mital et al. (1993)

also stated that taller individuals are relatively weaker in lifting strength than shorter individuals. In a study comparing sciatic pain in concrete reinforcement work and house painting, Riihimaki et al. (1989) found a higher incidence in the concrete reinforcement workers. Body height and a previous history of stress were found to be associated with an increase in the risk of contracting sciatic pain.

Several studies have been done on backache in drivers of different occupations. Anderson (1992) found that bus drivers (80.5%) experienced more mild back pain than non-drivers (50.7%) over a one year period. Severe pain, however, was similar (about 10%). In a study done on long distance drivers, Kompier et al. (1987) found that 82% of all long distance drivers reported musculoskeletal disorders. Four common areas of pain were identified as lower back, neck, shoulders and the thoracic area of the back. In a study done by Burdorf and Zondervan (1990), the prevalence of back pain was compared between crane drivers and a control group of non-drivers, engaged in light work. Previous heavy physical work and frequent lifting were significantly associated with lower back pain in the crane drivers. Age was not associated with back pain. The authors concluded that working as a crane operator is a significant risk factor for lower back pain.

In his review article Burdorf (1992) reported that the mechanical load placed on the spine in the working environment is considered an important cause of adverse conditions of the lower back. This included heavy physical work, frequent bending and twisting, repetitive work, lifting and forceful movements, vibration and static work postures. The author however cautioned that the main drawback of epidemiological studies in occupational health, is the poor quality of exposure data.

Andersson (1979) divided occupational risk factors for lower back pain into two categories, namely workplace factors (jobs with high physical demand, prolonged static work postures, flexed work postures, sudden and unexpected high physical work loads and vibration in the work place) and individual factors (poor abdominal and back muscle strength, postural deformities, such as kyphosis, spinal defects, such as spondylolysis and spondylolisthesis, psychological disposition, social factors, demographic factors and education). The author concluded that epidemiological studies are impeded by the problems surrounding the classification and diagnosis of lower back disorders, the causes of lower back disorders as well as the difficulty in objective measurement of loads on the spine.

Magora (1973a) concluded that risk factors for lower backache include sedentary occupations, lifting a weight with the spine flexed, lifting a weight with the spine in rotation or lifting while reaching forward and sudden unexpected maximal efforts, causing sudden strain in the soft tissues surrounding the spine. Psychological and emotional factors also play a role in lower backache (Magora, 1973b), especially in persons not happy in their present occupations, place of employment or their social status. The author suggested that further studies regarding the relationship between psychological factors and lower backache should be conducted.

In an epidemiological study of lower back pain, Frymoyer et al. (1980) concluded that physical occupational factors such as truck driving, lifting, pushing, pulling, carrying of heavy weights, twisting of the spine while lifting and vibration (such as working with a jackhammer) were risk factors for lower back pain. Other risk factors such as anxiety, depression and emotionally stressful occupations were also identified. Cigarette smokers, especially when accompanied by a chronic cough were also under risk of lower back pain. Many of these factors were identified again in a similar survey by Frymoyer et al. (1983). In their survey Frymoyer et al. (1983) found relationships between lower backache and jobs requiring heavy lifting, vibration, driving and cigarette smoking. From their literature review the authors also identified spine geometry, increased lumbar lordosis, repetitive heavy lifting, certain mechanical stresses, sedentary lifestyles, poor abdominal muscle tone, obesity, certain personality types and psychological stress as important risk factors for lower backache.

Linton (1990) found that monotonous work, heavy lifting and uncomfortable working postures contributed to both lower back and neck pain. Age was also seen as a risk in older and younger workers, but not in middle-aged workers.

In a study done by Marras et al. (1993) it was concluded that there is an association between biomechanical factors and the risk of lower back pain. These factors were identified as the lifting frequency, the load moment, trunk lateral velocity, trunk rotation velocity and the trunk sagital angle. The conclusion of this study was that by varying the combination of these biomechanical trunk motion factors, the risk of injury can be reduced.

1.7.3. Low Back Pain and Nursing

Many nurses accept that low back pain is "part of the job", and they learn to live with the problem (Pheasant and Stubbs, 1992). The authors remarked that nurses also take substantially less sick leave than the general population (about 40% less). However, sick leave due to low back pain is much higher in the nursing profession (about 30% more), than the general population.

Nurses are specifically in a high risk group for sustaining low back pain, often attributed to the physical demands of the job, particularly in patient lifting tasks (Pheasant, 1991). Several researchers (Cust et al., 1972, Stubbs et al., 1983a,b, Skovron et al., 1987, Dehlin et al., 1976, Magora, 1970, and Hignett, 1996a,b). reported that lower backache is still regarded as an occupational hazard in nursing. Some lifting is done in an emergency situation where it is not always possible to summon help, or apply correct body mechanics for the manual handling task. Videman et al. (1989) concluded that nurses with better patient handling skills are at a lower risk of sustaining a low back injury, compared to those with poor patient handling skills.

Lifting a patient is not necessarily only overcoming a heavy weight (Bell, 1987). Size, shape, lower limb function, balance, mental competence, physical dependence, co-ordination and co-operation also play a big role. Some patients can be confused or uncooperative and interfere with the lift or transfer. They can also resist movement and/or grab the nursing staff, therefore throwing them off balance. Correct body mechanics can also not always be applied due to problems such as space limitations, equipment and/or patient interference, non-height adjustable beds, chairs and commodes (Garg and Owen, 1992).

The belief held by nurses that back injuries will be prevented if proper lifting techniques and correct body mechanics are used is incorrect. Some patient handling tasks are so stressful that injuries occur even when the circumstances are perceived to be correct (Garg et al., 1991a,b and Stubbs et al. 1983b). Garg (1990) also states that there is a lack of consensus on proper lifting techniques amongst researchers. There is also no scientific evidence that correct training in manual handling techniques is effective in preventing the incidence of lower backache and injuries (Garg, 1990).

An ergonomic approach should be applied to reduce the incidence of lower backache in the nursing environment (Stubbs et al., 1983a,b, Harber et al., 1985, Garg et al., 1992, Pheasant and Stubbs, 1992 and Shaba, 1995, Hignett, 1996a,b). The task should be designed so that it is within the physical capabilities of the workers and reduces the mismatches between the physical demands of the job and the ability to perform the necessary tasks. Safer and more efficient methods of handling patients should be applied to reduce the stressful manual handling situations. In their conclusions, Garg and Owen (1992) reported that the back injury rate reduced significantly after ergonomic intervention was introduced into 2 units in a large nursing home (47 per 200 000 work-hours, compared to 83 before intervention).

In a review of back pain in the nursing profession, Buckle (1987) found an annual prevalence of 400 - 500 per 1000 at risk, with approximately 764000 working days per year being lost to the UK health service. Of the nurses leaving the profession, 0.8% cited lower backache as the sole reason, while 3.5% reported back pain as a main or contributory reason.

After reviewing Workers' Compensation records for back injuries from a large university hospital in Iowa, USA, for a 2-year period, Fuortes et al. (1994)

reported that lost work time by nurses due to back pain was 2%, exceeded only by the physical plant staff (3.5%). They also reported that nurses' aids who traditionally perform the more physical tasks in nursing, had an injury rate of 3.3-fold higher than registered nurses and licensed practising nurses, and higher than any other occupational group. Important risk factors were identified as lifting and twisting activities, as well as being overweight.

In a study involving 813 nurses at an Australian hospital it was concluded that 87% of the participants had experienced at least one episode of back pain during their lifetime. Forty-two percent had an episode of low back pain within the previous month or at the time of the survey and 53% of these nurses with low back pain reported that the injury was sustained during normal nursing duties (Arad, 1986 cited in Fuortes et al., 1994).

Knibbe and Friele (1996) concluded in their study on back pain prevalence of community nurses, that training in coping with the unpredictable workload alone, is not the answer. The postural loads imposed, and the task demands should be decreased by implementing ergonomic measures.

In a survey of hospital workers, Burgmeier et al. (1988) concluded that heavy work, age, sex and length of service were important contributors to the prevalence of back pain. Obesity and previous episodes of lower back pain were also considered as contributors of lower back pain.

Ahlberg-Hultén et al. (1995) concluded in their study that low back pain was mainly due to occupational factors, while neck and shoulder symptoms were mainly related to emotional and relational stress. A similar conclusion was reached by Viikari-Juntura et al. (1991), where low fundamental education was also implicated as a predictor for low back pain.

In a study assessing occupational lifting by nursing aides and warehouse workers, Ljungberg et al. (1989) found that more nursing aides than warehouse workers reported lower back problems even though the warehouse workers performed four times more lifts than the nurses. The lifting done by the nurses was of longer duration and more frequently also under sudden unexpected high peak loads. The lifting and carrying done by the nurses were also often performed in awkward postures and maintained for a prolonged period of time.

Dehlin and Berg (1977) reported in their study on the psychological aspects of back pain in nursing that nurses with thoracic and lower back pain had a lower level of work satisfaction. They also perceived the job as needing more physical and mental strength than other jobs. The authors argued that it could not accurately be determined whether symptoms were caused by physical or psychological factors. These factors may have been present at the same time and also influenced each other.

In a study conducted by Harber et al. (1985) it was found that 52% of ward nurses experienced low back pain due to occupational activities in the last six months. In contrast, only 20% of the ward managers reported lower back pain. More than 40% of the ward nurses reported at least one incident of pain in the previous 2 weeks due to their work. The authors remarked that these injuries were often unreported and could have contributed to decreased worker efficiency. Pheasant and Stubbs (1992) also found that the injury rate for low back pain was the highest in nursing auxiliaries, followed closely by student nurses and the staff nurses. The injury rate in ward sisters was negligible. Shaba (1995) found that senior assistant nurses had the highest complaint rate of lower back pain and also the most sick leave days due to lower back pain. A further finding was that in the related 3-year period the number of complaints about lower backache rose from 14.6% to 48.4%. Sick leave due to lower backache rose from 13.7% to 46.1% as a percentage of the total sick leave taken during the same period.

Harber et al. (1987) reported that not only general nursing tasks contributed to the incidence of lower back pain. Other risky occupational activities included moving (carrying and pushing) furniture, equipment and beds, particularly in smaller, more cramped wards, standing, walking, headaches and job frustration.

1.8. Ergonomics and the Survey of Nurses in South Africa

From the literature it can be seen that there is still a vast amount of research needed about human variability. Anthropometric characteristics are needed to properly design workplaces and equipment for specific populations of workers. Anthropometric data are also needed to assess the loading imposed on the joints of workers during the performance of work. Al-Haboudi (1992) emphasises that anthropometrists should address the user population of an intended system when designing, irrespective of their ethnic backgrounds.

Very few anthropometric surveys have been done on females in South Africa. All of the studies that were done were related to the design of clothing. No anthropometric studies have been done on female nurses.

The RSA military standard (1995) contained the data from a survey gathering anthropometric measurements specifically related to the design of clothing and combat gear. Sixty-seven anthropometric variables related to clothing design were taken. The data were collected from a sample group of 1845 females in 36 different occupations, with only one third of the sample working as soldiers and the rest in other occupations such as social work and cleaning. Because of dimensional differences between race groups, the groups were divided into white (531), coloured (233) and black (1091). The subjects were employees in the Air Force, Navy, Army and Medical Service of the South African Defence Force.

The Department of Prison Services (SABS, 1989) conducted an anthropometric survey on uniformed female staff with the specific objective of designing new uniforms. Three hundred and forty three warders (236 white, 49 coloured and 58 black members) from 6 different prisons were measured. A total of 25 anthropometric measurements, all related to clothing design, were taken. Body size tables were produced for the different race groups and standard fitting tolerances for each garment incorporated to design the uniforms.

Anthropometric studies were carried out on groups of young children in the 1960's and 1970's (Smit et al., 1967a, Smit et al., 1967b, Smit, 1971, Smit 1973, Leary, 1968).

As seen from the literature review, very few anthropometric studies have attempted to formally relate human variability to specific dimensional mismatches which have consequences for system functioning, e.g.: more errors, more accidents, more disease, more pain or usability problems.

This current project is an attempt to sample the nursing population in the Western Cape anthropometrically in the light of the paucity of data on women in general and nurses in particular in South Africa. The central thrust is to identify the key mismatches between the nursing personnel and work spaces and equipment and musculoskeletal pain and relate these to the anthropometry of the workforce.

2. Method

2.1. General Approach

The largest number of nurses in the Western Cape are in the public service. Despite great effort to conduct part of this study in a public service hospital, the length of time required to get permission at the appropriate seniority level, would have made it very difficult to include them in this survey. Access to the nursing staff in the private sector proved to be much easier due to the less rigid organisational hierarchy.

100 full time general ward and theatre nurses (hereafter only referred to as ward nurses) of all population groups participated in the study on a voluntary basis. They were recruited by means of an invitation circulated by the hospital matrons in 3 private hospitals. These hospitals employ a total of 162 full time nurses. The sample constituted 62% of the total number of full time nurses employed in the participating hospitals. Each nurse was requested to participate in the anthropometric survey, to be observed at work and also to complete the questionnaire (see appendix 2). In each hospital a room was set aside for the anthropometric measurements. After the measurements were made, the nurses were given the questionnaire to complete before returning to their duties. Due to staff shortages and other constraints, 12 nurses were unable to complete the questionnaire on site. Four nurses did not complete the questionnaire and 8 only gave details of length of service and place of birth. The questionnaire was also completed by a group of 22 trained nurses presently employed in mainly sedentary jobs as nursing managers and teachers (hereafter referred to only as nursing managers). This was done to get a baseline response to the questions from a similar group of people who are not exposed to the physical stresses of daily ward and theatre work.

2.2. Sample

The selection was on a voluntary basis. The sample was not broken up into different race groups, but measured as one Western Cape population group.

This was done firstly because the sample is small, and secondly and very importantly because there is no segregation by race or ethnicity in the work place and therefore in the author's opinion, no reason to segregate the sample in this manner. Ellison et al. (1996) stressed that researchers should not use categories based on race or ethnicity when collecting data in the South African health context, as it is viewed as being discriminatory. Health research should be aimed at redressing this discrimination, by eliminating data collection based on segregation. The current view appears to be that it is up to those who wish to partition their samples along racial or ethnic lines to motivate doing so and to be prepared to defend the practice against criticism. The "Black, White, Coloured and Indian" racial/ethnic categorisation scheme used by the previous government is not based on scientific grounds and is arguably, arbitrary.

The nurses were individually measured and the measurements recorded by an assistant. During the measuring procedure, the subjects were minimally clothed, bare-headed and without shoes. All the standing and sitting surfaces were flat, horizontal and non-compressible. Where unilateral measurements were taken, these were all taken on the right side of the body.

2.3. Questionnaires (see appendix 1)

The core items in the questionnaire were obtained from Pheasant (1987). The final questionnaire was designed, after consultation with Dr Pheasant, to elicit information about tasks and equipment used in a normal shift. In the first part of the questionnaire, open-ended questions were used to elicit information about usability problems, i.e. no items of equipment or specific nursing tasks were explicitly mentioned. This was done in order to ascertain when, how and where anthropometrics place constraints on usability and performance. A final section on hospital beds was included however.

The questionnaire included items concerning the following:

- Working postures and job activities (e.g. is your job mainly sitting or standing, do you have problems reaching for work objects?).

- Problems due to the dimensions of equipment used (e.g. are there handles that hurt your hands, are there work areas that are too high or too low, can you rest your feet comfortably on the floor when sitting on your chair?).
- Other design problems (e.g. is "portable" equipment too heavy, are beds easy or difficult to adjust?).
- Injuries and pain (body regions: lower back, mid back, neck, shoulder, arm, hand, leg and foot).
- Lifting and manual handling (availability, type and usability of lifting aids, training in manual handling).
- Selected problems of daily living (e.g. clothing and shoes).
- Place of birth.
- Length of time in nursing.

2.4. Assessments of the workstations

Observations of nurses at work were carried out to identify equipment usability problems (e.g. size and weight of equipment) as well as the manual handling techniques used. Physical measurements of the workstations were also made e.g. space, reach distances, clearance, heights and storage facilities. Photographs of specific nursing tasks and workspace designs were taken. These assessments were made in representative working areas of participating hospitals, including general wards, operating theatres, high care wards, sluice rooms, nurses' station and linen storage.

2.5. Anthropometric Dimensions

The ISO (1992) and NASA (1978) have published lists of anthropometric dimensions to be made in ergonomic surveys. Only static measurements were chosen as this project was restricted to work station design. Measurement for the design of clothing, shoes and protective gear design was considered a separate issue.

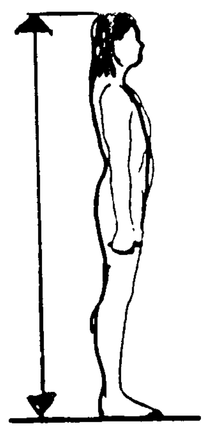
The following measurements were chosen on the basis of the observational assessments:

2.5.1. <u>Stature</u>

Definition: The vertical distance from the floor to the vertex.

Application: Defines the vertical clearance required in the standing workplace – the minimal acceptable height of overhead constructions.

Method: The subject stands fully erect with the feet together. The head is orientated in the Frankfurt plane. This is the standard horizontal plane of orientation of the head. The plane is determined by the two tragions (approximate ear hole) and the lowest point of the right orbit (eye socket).

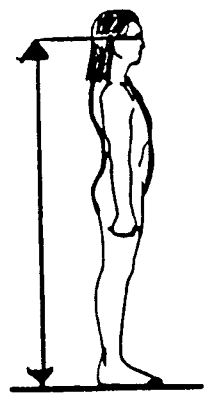


2.5.2. Eye height (standing)

Definition: The vertical distance from the floor to the inner canthus (corner) of the eye.

Application: Centre of visual field. This defines maximal acceptable height of visual obstructions and location of visual displays for standing operators.

Method: The subject stands fully erect with the feet together. The head is oriented in the Frankfurt plane.

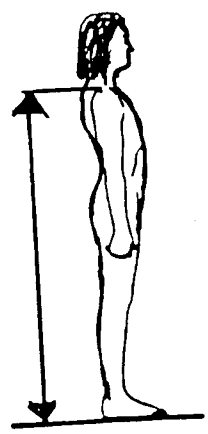


2.5.3. Shoulder height

Definition: The vertical distance from the floor to the tip of the acromion.

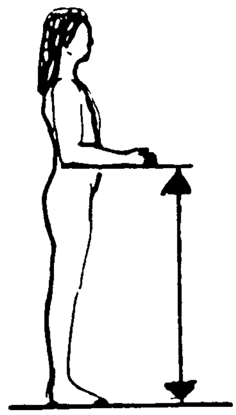
Application: Used in determining zones of comfortable reach - reference for placement of fixtures, fittings and controls to allow shorter workers to operate below shoulder height.

Method: The subject stands fully erect with the feet together.



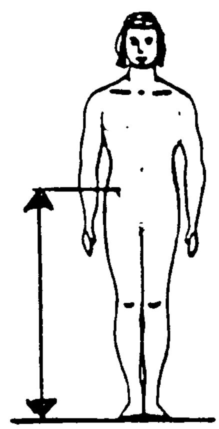
2.5.4. Elbow height

Definition: The vertical distance from the floor to the tip of the olecranon process of the bent elbow.
Application: Applies to work surface height for standing workers.
Method: The subject stands fully erect with the feet together. The upper arm hangs freely downwards, the forearm is flexed at right angles to it.



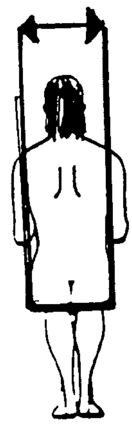
2.5.5. Hip height

Definition: The vertical distance from the floor to the greater trochanter.
Application: The functional length of the lower limb.
Method: The subject stands fully erect and the greater trochanter is palpated on the lateral surface of the hip.



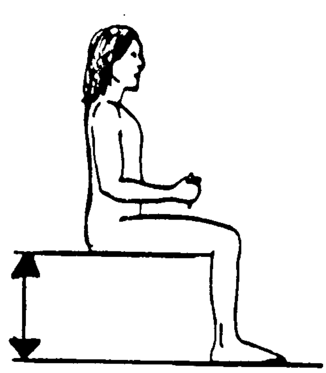
2.5.6. Hip Breadth (sitting)

Definition: The maximum horizontal distance across the hips in the sitting position.
Application: Applies to the minimum width of seating (clearance at seat level).
Method: The subject sits with the thighs fully supported; lower legs hanging free and the knees together. The measurement is taken without pressing into the soft tissue hips.



2.5.7. Popliteal Height

Definition: The vertical distance from the floor to the popliteal angle at the underside of the knee where the tendon of the biceps femoris muscle inserts into the lower leg.
Application: Applies to height of chairs.
Method: In sitting, the subject holds the thigh and lower leg at right angles and supports the feet on the floor with the ankles at right angles. The movable arm of the measuring instrument is pushed gently against the tendon of the relaxed biceps femoris tendon insertion.

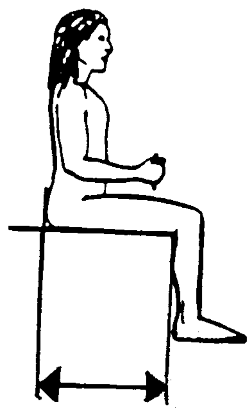


2.5.8. Buttock-popliteal length

Definition: The horizontal distance from the back of the uncompressed buttocks to the popliteal angle.

Application: Applies to seat depth.

Method: The subject sits with the thighs fully supported and the sitting surface extending as far as the popliteal fossa, with the lower legs hanging freely. The position of the rearmost point of the buttock is vertically projected into the sitting surface by means of a measuring block which touches the buttocks. The distance is measured from the measuring block to the forward edge of the sitting surface.

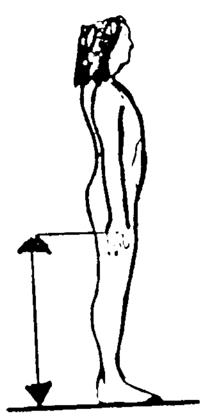


2.5.9. Standing Knuckle height

Definition: The vertical distance from the floor to the distal point of the third metacarpal.

Application: Reference level for handgrips and support, also the optimal height for exertion of lifting.

Method: The subject stands fully erect with the shoulders relaxed and the arms hanging down freely.

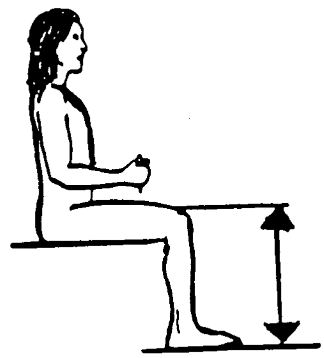


2.5.10. Knee height

Definition: Vertical distance from the floor to the upper surface of the patella.

Application: Clearance required beneath the underside of tables, desks and other objects.

Method: The subject sits erect with the knees bent at right angles and supporting the feet on the floor with the ankles at right angles.

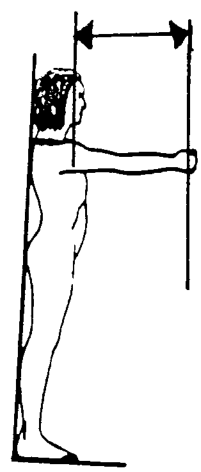


2.5.11. Shoulder-handgrip length

Definition: Distance from the tip of the acromion to the centre of a rod gripped in the hand (fist grip), with the elbow and wrist straight.

Application: The functional length of the upper limb, as this defines the zone of convenient reach.

Method: The subject stands fully erect gripping a rod vertically in the hand, with the elbow in full extension and the arm parallel to the floor.

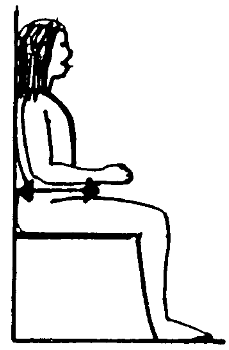


2.5.12. Elbow-wrist length

Definition: The horizontal distance from the tip of the olecranon to the styloid process of the ulna.

Application: Length of armrest of chair.

Method: The subject sits or stands erect, back to the wall. The right arm hangs down freely, elbow touching the wall, with the forearm bent at a right angle to the wall.

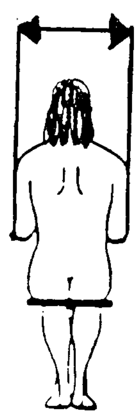


2.5.13. Elbow-to-elbow breadth

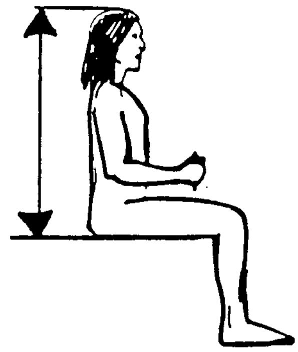
Definition: The maximum horizontal distance between the lateral surfaces of the elbow region, at the lateral epicondiles.

Application: Seat width.

Method: The subject sits erect with the upper arms hanging vertically down and lightly touching the sides of the body. The forearms are at right angles to the upper arms and parallel to each other. The measurement is taken without pushing into the soft tissue at the elbows.

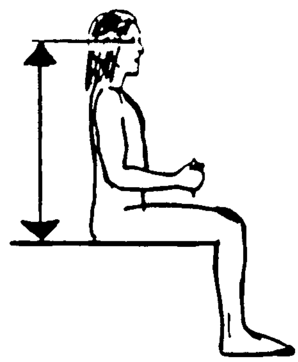


2.5.14. Sitting height (erect)



Definition: The vertical distance from a horizontal sitting surface to the vertex.
Application: Applies to head clearance.
Method: The subject sits fully erect and the head orientated in the Frankfurt plane. The thighs are fully supported and the lower legs hang freely.

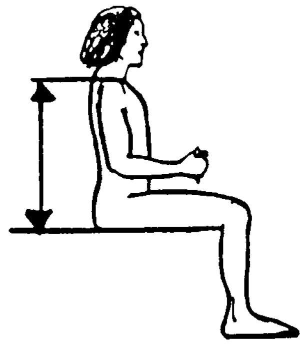
2.5.15. Sitting eye height



Definition: The vertical distance from a horizontal sitting surface to the inner canthus of the eye.
Application: Centre of visual field (i.e. VDU work).
Method: The subject sits fully erect and the head orientated in the Frankfurt plane. The thighs are fully supported and the lower legs are hang freely.

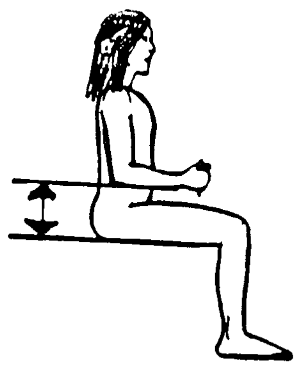
2.5.16. Sitting shoulder height

Definition: Vertical distance from the seat surface to the tip of the acromion.
Application: Applies to reach in the sitting position.
Method: The subject sits fully erect. The thighs are fully supported and the lower legs hang freely. The shoulders should be relaxed and the arms should be hanging freely.



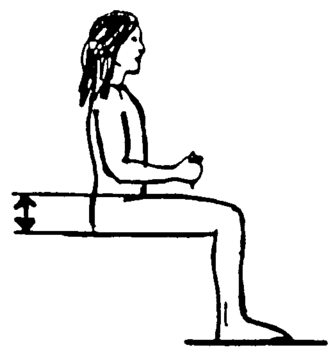
2.5.17. Sitting elbow height

Definition: Vertical distance from the seat surface to the tip of the olecranon process of the bent elbow (also known as elbow rest height).
Application: Height of armrests, desktops, keyboards etc.
Method: The subject sits fully erect with the thighs fully supported. The upper arm hangs freely downwards, and the forearm is bent at right angles to it.



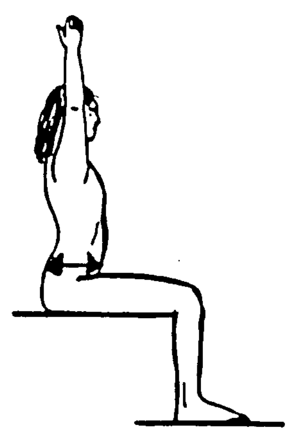
2.5.18. Thigh clearance

Definition: Vertical distance from the seat surface to the highest point of the quadriceps muscle (generally where the thigh meets the abdomen).
Application: The clearance required between the thigh and the underside of the worktop.
Method: The subject sits erect with the knees bent at right angles and supporting the feet on the floor with the ankles at right angles.



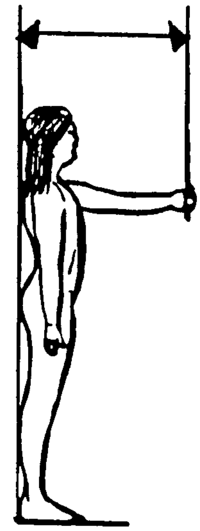
2.5.19. Abdominal depth (sitting)

Definition: The horizontal depth from the lumbar spine to the maximum protrudence of the abdomen while sitting.
Application: Clearance between the seatback and obstructions.
Method: The subject sits erect with both hands reaching above the head. The measurement is taken without pushing into the soft tissue of the abdomen.



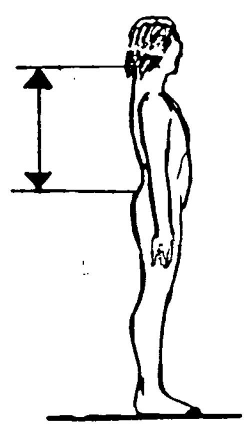
2.5.20. Grip reach

Definition: The horizontal distance from a vertical surface to the grip of axis of the hand while the subject leans both scapulae against the vertical surface.
Application: Reach to objects without excessive stretch.
Method: The subject stands erect with heels and buttocks touching the vertical surface. The arm is fully extended horizontally. The hand holds the measuring rod upright while the hand is aligned along the long axis of the forearm.



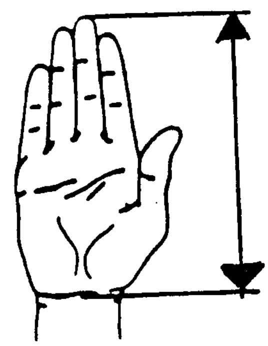
2.5.21. Trunk length (Spine length)

Definition: The distance from the spine of the first cervical vertebra to the spine of the fifth lumbar vertebra while the subject is standing erect.
Application: Significant in biomechanical modelling of manual lifting and estimating the trunk centre of gravity.
Method: The subject stands fully erect. The spines of C1 and L5 are identified by palpation.



2.5.22. Hand length

Definition: The distance from the tip of the middle finger to the most distal point of the styloid process of the radius, measured with the hand outstretched.

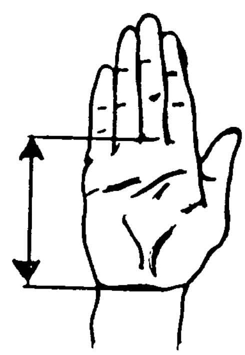


Application: Design of gloves, also grip and strength.

Method: The subject holds the forearm horizontal with the hand outstretched, palm up. The point of measurement at the styloid process corresponds approximately to the middle skin furrow of the wrist.

2.5.23. Palm length

Definition: The distance from the most distal point of the styloid process of the radius to the proximal crease of the middle finger on the palm of the hand.



Application: Design of gloves, also grip i.e. handles.

Method: The subject holds the forearm horizontal with the hand outstretched. The measurement is taken on the inner surface of the hand. The fingers are spread out.

2.5.24. Hand breadth at metacarpal

Definition: The distance along a straight line between radial and ulnar metacarpals at the level of the metacarpal heads from the second to the fifth.

Application: Design of gloves, also clearance required for hand access.

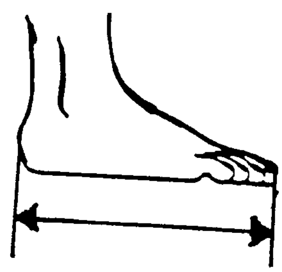
Method: The subject holds the forearm horizontal with the hand stretched out flat, palm up.

2.5.25. Foot length

Definition: The maximum distance from rear of the heel to the tip of the longest (first or second) toe, measured parallel to the longitudinal axis of the foot.

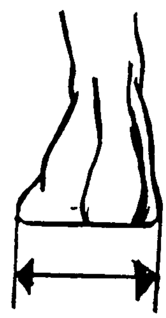
Application: Design of footwear, also clearance for feet and design of pedals.

Method: The subject stands with weight equally distributed on both feet.



2.5.26. Foot breadth

Definition: Maximum distance between the medial and lateral surfaces of the foot perpendicular to the longitudinal axis at the foot.



Application: Design of footwear, also clearance for feet and spacing of pedals.

Method: The subject stands with the weight equally distributed on both feet.

2.5.27. Body Mass

Definition: Total body mass (weight) of the body.

Application: Important in screening for unusual growth, obesity and undernutrition.

Method: The subject stands on a weight scale.

2.5.28. Age

Definition: The chronological age of the individual.

Application: Range of age group of the sample.

The specifications of measurements are described in the ISO document 7250.2, guidelines in NASA 1024 (1978), Bodyspace (Pheasant, 1986 &1996) and W. Marras and J. Kim (1993).

2.6. Measuring tools

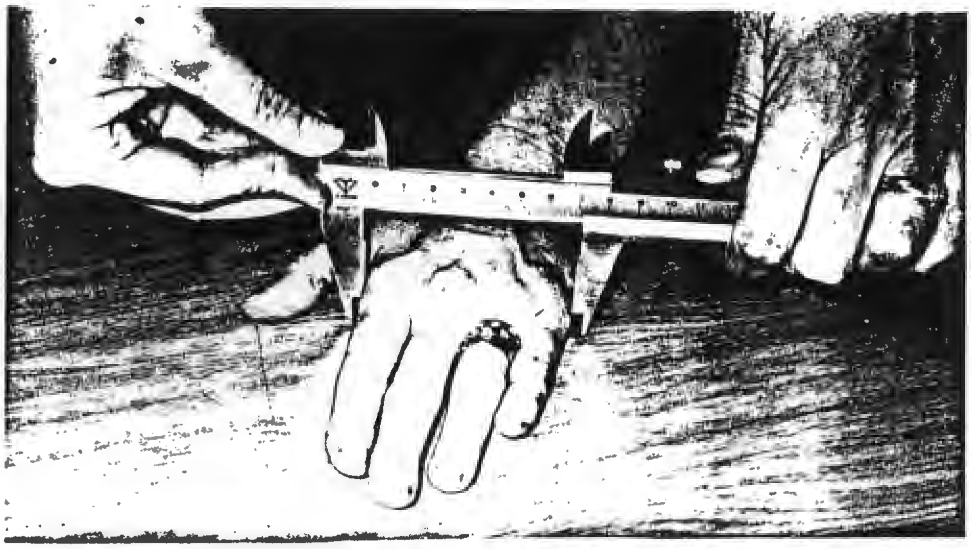
The following tools were used:

2.6.1. Anthropometer - for measuring linear distances between points on the body and standard reference surfaces such as the floor or a seat platform. This is illustrated in Figure 1.

Figure 1.

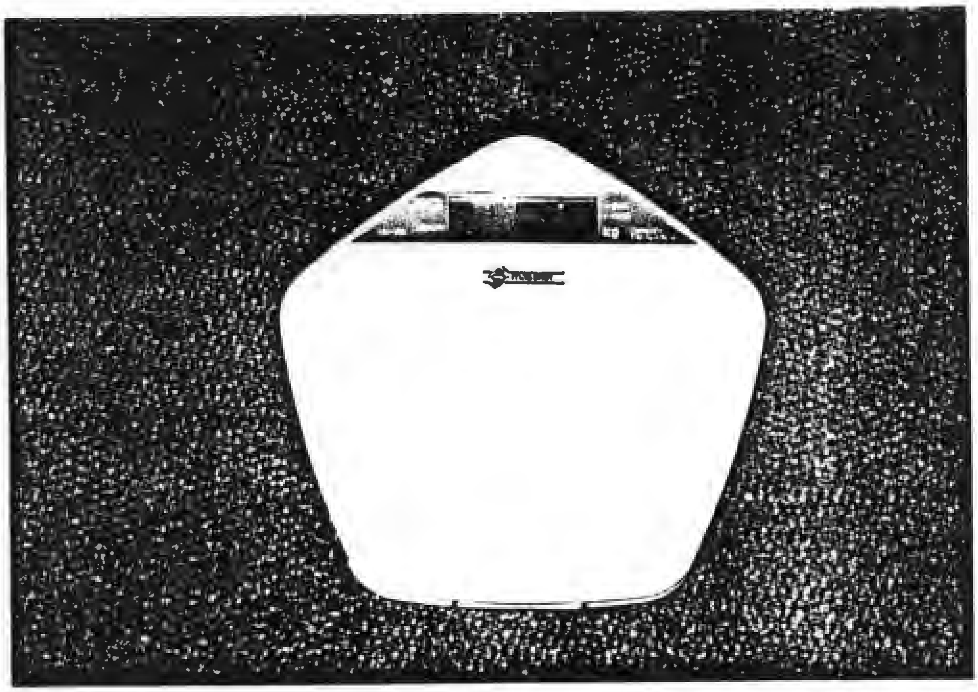
2.6.2. Sliding and spreading callipers - for measuring breadth and depth of body segments as well as the distance between reference marks. The use of the callipers is illustrated in Figure 2.

Figure 2.



2.6.3. An UC-300 Precision Health Scale was used for measuring body mass. This is presently the most accurate portable scale and displays increments of 50 grams. The scale is illustrated in Figure 3.

Figure 3.



2.6.4. 200 mm cubic measuring block - to determine maximum posterior protrusion of a sitting person. The use of the measuring block is illustrated in Figure 4.

Figure 4.

3. Results and Discussion

The data were analysed in different stages, firstly the anthropometric data, next the questionnaire and finally, the tests of association between the anthropometric data and the questionnaire responses.

The anthropometric data were gathered and analysed to ascertain the size and variability of the people in the sample and perhaps to compare the data with other populations. Unfortunately no comparative data specifically on nurses could be found.

In the next stage the questionnaires were analysed to find out about any problems in using equipment or arising out of equipment use. This was contrasted with the responses of the nursing managers to check for response bias.

Finally, mismatches between the dimensions of equipment and work areas and physical dimensions of the nurses were analysed and recommendations made.

3.1. Anthropometric data

The anthropometric data were analysed using Statgraphics and the descriptive statistics extracted the mean ($\bar{x}$) and standard deviation (SD) of each variable. A correlation matrix was generated (see page 51). In the correlation matrix it is clear that certain dimensions correlate highly with each other, such as dimensions which depend on long bone growth, and dimensions which depend on the extent of the presence of soft tissue. Examples of correlation between long bone measurements include the following: Stature and Standing shoulder height (0.95), Stature and Eye height standing (0.9), Stature and Hip height (0.82) and Stature and Sitting height (0.76). Examples of correlation between soft tissue measurements include the following: Hip breadth and Elbow-elbow breadth (0.67), Hip breadth and Thigh clearance (0.64), Hip breadth and Abdominal depth (0.76) and Hip breadth and Body weight (0.76). No significant correlation was found between long bone and soft tissue dimensions e.g. Stature and Hip breadth (0.07).

3.1. Anthropometric Data

Table 1a. A Summary of Statistics of Female Nurses working in the Western Cape
(All dimensions in millimetres, except Body mass in kilograms, Age and Years of Service in years and Body Mass Index in kg/m²)

	$\bar{x}$	SD	Min	Max	Low Quad	Upper Quad	5th %ile	95th %ile
1. Stature (**S**)	1630	65	1506	1816	1579	1674	1523	1737
2. Eye height (standing) (**SHS**)	1521	66	1388	1710	1464	1570	1412	1629
3. Shoulder height (**SH**)	1355	59	1247	1532	1306	1398	1259	1451
4. Elbow height (**EH**)	1003	49	889	1137	965	1035	923	1082
5. Hip height (**HH**)	874	47	789	996	836	902	797	951
6. Hip breadth (sitting) (**HB**)	421	46	319	560	388	454	346	496
7. Standing Knuckle height (**SKH**)	722	43	621	827	692	748	651	792
8. Shoulder handgrip length (**SHL**)	587	36	521	748	565	602	529	646
9. Elbow-wrist length (**EWL**)	243	16	154	289	235	252	216	267
10. Grip reach (**GR**)	689	40	531	811	674	716	623	755
11. Trunk length (**TL**)	556	45	445	691	524	582	483	629
12. Foot length (**FL**)	243	16	194	293	232	252	216	269
13. Foot breadth (**FB**)	95	12	61	136	89	100	76	114
14. Popliteal height (**PH**)	418	28	353	554	401	431	372	464
15. Buttock-popliteal length (**BPL**)	517	41	336	597	498	545	450	585
16. Knee height (**KH**)	539	31	434	607	520	560	489	589
17. Elbow-elbow breadth (**EEB**)	478	48	355	624	449	504	399	556
18. Sitting height (erect) (**SHE**)	849	36	774	938	823	876	790	908
19. Sitting eye height (**SE**)	738	38	669	853	711	762	676	801
20. Sitting shoulder height (**SSH**)	580	36	507	697	555	599	520	640
21. Sitting elbow height (**SEH**)	234	33	167	341	209	256	180	287
22. Thigh clearance (**TC**)	165	21	106	211	149	183	130	199
23. Abdominal depth (**AD**)	270	54	185	478	232	296	181	359
24. Hand length (**HL**)	184	11	151	205	177	192	165	203
25. Palm length (**PL**)	109	11	62	128	105	116	92	127
26. Hand breadth (**HAB**)	81	8	42	98	78	85	69	93
27. Body Mass (**W**)	72	18	41	120	61	80	42	102
28. Age	39	9	24	58	33	46	25	54
29. Body Mass Index (BMI)	26.67	5.52	16.87	48.19	22.45	30.89	17.62	35.72
30. Years of Service	17	8	2	40	9	22		

Table 1b. Correlation Matrix (* denotes no statistical significance, p>0.05).

	Correlation Coefficients																										
	S	SHS	SH	EH	HH	HB	SKH	SHL	EWL	GR	TL	FL	FB	PH	BPL	KH	EEB	SHE	SE	SSH	SEH	TC	AD	HL	PL	HAB	W	AGE
S	1																											
SHS	0.95	1																										
SH	0.95	0.92	1																									
EH	0.9	0.88	0.88	1																								
HH	0.82	0.8	0.8	0.83	1																							
HB	0.07*	0.02*	0.08*	0.06*	0.03*	1																						
SKH	0.85	0.84	0.87	0.92	0.72	0.08*	1																					
SHL	0.62	0.6	0.63	0.54	0.57	-0.01*	0.46	1																				
EWL	0.27	0.26	0.23	0.19*	0.19*	-0.14*	0.11*	0.23	1																			
GR	0.37	0.31	0.32	0.26	0.26	0.15*	0.11*	0.14*	0.32	1																		
TL	0.73	0.74	0.69	0.64	0.49	-0.12*	0.61	0.52	0.15*	0.23	1																	
FL	0.45	0.39	0.42	0.34	0.33	0.4	0.31	0.35	0.04*	0.23	0.33	1																
FB	0.08*	0.06*	0.08*	0.03*	-0.01*	0.32	0.06*	0.15*	-0.10*	0.05*	0.04*	0.7	1															
PH	0.64	0.63	0.6	0.6	0.58	0*	0.52	0.42	0.17*	0.15*	0.43	0.26	0.05*	1														
BPL	0.4	0.41	0.38	0.36	0.4	0.29	0.28	0.35	0.06*	0.2	0.26	0.15*	-0.15*	0.34	1													
KH	0.56	0.56	0.55	0.52	0.55	0.31	0.42	0.38	0.09*	0.28	0.38	0.38	0.12*	0.61	0.32	1												
EEB	0.02*	-0.04*	0.03*	0.03*	-0.04*	0.67	0.05*	0.01*	-0.13*	0.15*	-0.10*	0.44	0.36	-0.07*	0.14*	0.15*	1											
SHE	0.76	0.73	0.76	0.72	0.52	0.22	0.75	0.42	0.09*	0.23	0.6	0.4	0.24	0.4	0.19*	0.37	0.11*	1										
SE	0.68	0.65	0.66	0.64	0.43	0.22	0.68	0.33	0.13*	0.19*	0.55	0.35	0.18	0.35	0.13*	0.36	0.14*	0.9	1									
SSH	0.55	0.5	0.62	0.6	0.4	0.14*	0.61	0.37	0.12*	0.10*	0.49	0.28	0.2	0.29	0.11*	0.26	0.13*	0.76	0.76	1								
SEH	0.17*	0.14*	0.31	0.31	0.06*	0.27	0.41	-0.01*	-0.10*	-0.09*	0.15*	0.11*	0.18*	0.01*	-0.10*	0.06*	0.35	0.6	0.6	0.71	1							
TC	0.16*	0.11	0.11*	0.21	0.13*	0.64	0.17*	0.02*	-0.06*	0.09*	-0.01*	0.18*	0.06*	0.17*	0.25	0.46	0.46	0.28	0.35	0.36	0.43	1						
AD	-0.12*	-0.16*	-0.16*	-0.11*	-0.12*	0.76	-0.06*	-0.07*	-0.21*	0.13*	-0.24*	0.32	0.44	-0.16*	0.14*	0.09*	0.73	0.06*	0.08*	0.08*	0.29	0.48	1					
HL	0.32	0.27	0.23	0.17*	0.16*	0.15*	0.13*	0.25	0.06*	0.16*	0.28	0.34	0.08*	0.22	0.22	0.17*	0.15*	0.15*	0.17*	0.03*	-0.12*	0.14*	0.01*	1				
PL	0.10*	0.07*	0.03*	0.07*	-0.08*	0.22	0.07*	-0.05*	0.02*	0.02*	0.11*	0.22	0.06*	0*	0.01*	0.05*	0.22	0.15*	0.24	0.15*	0.14*	0.3	0.15*	0.61	1			
HAB	0.07*	0.04*	0.06*	0.05*	0.01*	0.16*	0.08*	-0.08*	-0.20*	-0.06*	0.14*	0.17*	0.01*	-0.09*	0.10*	0.07*	0.25	0.01*	0.02*	-0.05*	0.05*	0.22	0.17*	0.4	0.41	1		
W	0.09*	0.06*	0.12*	0.11*	0.06*	0.76	0.12*	0.04*	-0.13*	0.19*	-0.09*	0.3	0.26	-0.04*	0.28	0.27	0.7	0.18*	0.22	0.19*	0.31	0.55	0.78	0.05*	0.16*	0.17*	1	
AGE	0.04*	0.02*	0.03*	-0.06*	0*	0.07*	-0.06*	0.13*	-0.03*	0.12*	0.12*	0.25	0.22	-0.02*	0.19*	-0.03*	0.13*	0.06*	0.06*	0.06*	0.03*	-0.06*	0.17*	0.11*	0.05*	0.10*	0.06*	1

3.2. Results of the Questionnaire

Eighty-eight subjects returned the full questionnaire (see Appendix 1) and 8 more gave details about length of service and place of birth. The questionnaire was also completed by 22 nursing managers. The data were analysed to characterise the subjects as well as the prevalence of particular problems at work and / or of daily living. The results are discussed under general problems related to activities of daily living and the working environment and then specifically related to pain and injuries and causes of other problems.

In the tables following each question section, the results of pain and problems related to work areas and workstations of the ward nurses are presented. Many subjects named more than one cause for the various problems experienced. The respondents did not always give examples of the causes of the problem areas.

Detailed findings follow and a summary of the main findings can be found in the section on Anthropometry, Nursing and changing populations in South Africa.

3.2.1. General

This section of the questionnaire contained general questions about place of birth, working posture and job activities, as well as selected problems of daily living.

The responses of the 2 groups were compared and the results of the analyses are presented in Appendix 3 and briefly summarised below. In this general section, the origins of the respondents in both groups are fairly similar. Nursing is a mobile profession, so this finding is not unexpected. One would not expect a difference in the difficulty with which the respondents are able to buy clothes and shoes in a shop ($p>0.05$ in both cases). Both groups experienced this problem in the same way. There was, however, a difference in the area of having to reach for work objects ($p<0.01$), as well as general working position ($p<0.01$). Ward nurses found that they have to reach for work objects often.

Ward nurses also spend most of their time standing at work. Most of the nursing managers are desk bound (mostly seated) and would presumably have all their work requirements close at hand and do not have to reach far or often. These differences are evidence that problems are often due to job content.

Table 2

Distribution of origin of the respondents.

Place of Birth	Ward Nurses (N=96)
Cape Town	41
Western Cape	9
Northern Cape	9
Gauteng	9
Eastern Cape	7
United Kingdom	6
Zimbabwe	5
Kwazulu-Natal	4
Namibia	2
Uganda	1
Germany	1
The Netherlands	1
New Zealand	1

From table 2 it can be seen that the sample is heterogeneous. Only 52% of the ward nurses are originally from the Western Cape. Thirty percent of the ward nurses originate from the rest of South Africa, 8% from the rest of Africa and 10% from Europe and New Zealand. In the group of nursing managers, 45% were from the Western Cape, 36% from the rest of South Africa, and 19% from outside the borders of South Africa.

The respondents were also essentially of a more mature population of qualified subjects (Age: $\bar{x}$ = 39 years, Years of service: $\bar{x}$ = 17 years). No trainees were measured, due to the problems getting access to a provincial government hospital.

Table 3

Main working position of the respondents.

Is the job mostly Standing or Sitting	**Ward Nurses (N=88)**
Mostly Standing	77
Mostly Sitting	2
Standing and Sitting	9

Table 4

Occurrence of problems reaching for work objects.

Problems reaching for objects at work	**Ward Nurses (N=88)**
Yes	38
No	47
Did not answer	3

Table 5

Occurrence of problems buying clothes in a shop.

Problems buying clothes in a shop	**Ward Nurses (N=88)**
Yes	26
No	61
Did not answer	1

Table 6

Problems experienced when buying clothes in a shop.

Examples of problems buying clothes in a shop	**Ward Nurses**
Trousers / Hems too long	8
Sizes too small	8
Hips bigger than chest measurement	3
Unusually lordotic lumbar spine	3
Hanging rails too high	2
Hips bigger than waistline	1
Sizes too big	1

Table 7

Occurrence of problems buying shoes in a shop.

Problems buying shoes in a shop	**Ward Nurses (N=88)**
Yes	34
No	53
Did not answer	1

Table 8

Problems experienced when buying shoes in a shop.

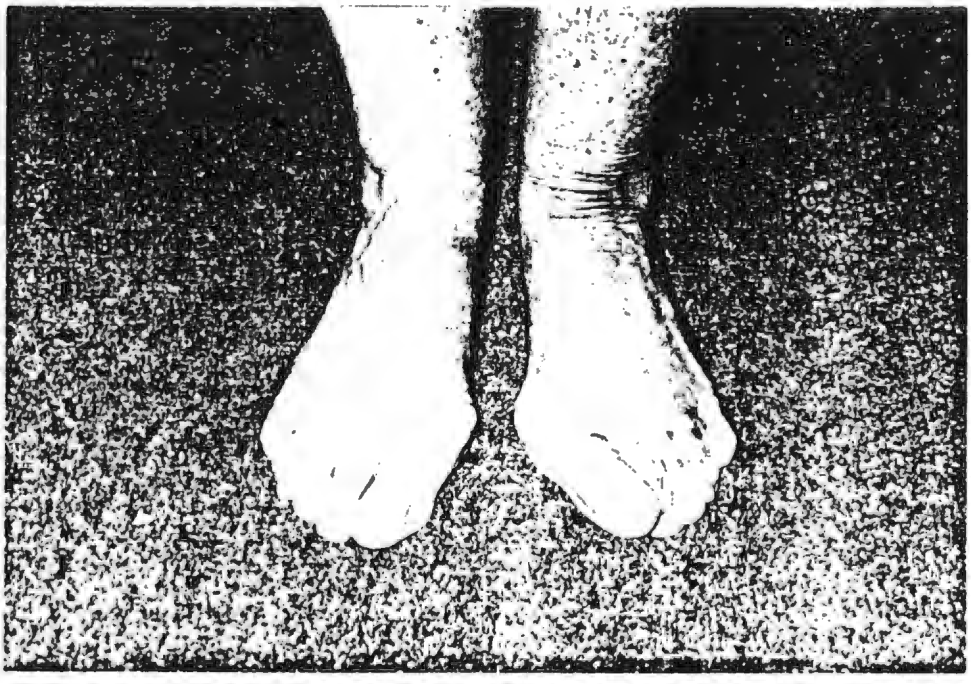
Examples of problems buying shoes in a shop	**Ward Nurses**
Wide feet	23
Sizes too small	6
Narrow feet	5
Bunions	4
High arches	2
Collapsed arches	1

As far as general variability is concerned, 30% of the sample reported problems buying clothes in a shop and 39% of the sample reported problems buying shoes in a shop. This is indicative of the extreme shapes present in this sample. It seems that current clothing and shoe design does not allow for much body size variability and/or that this variability is not acknowledged. Many locally produced shoes are made from imported lasts. These results also indicate that these extreme shapes will impact on the complaints and problems experienced in the working environment. Nurses stand most of their working day. By wearing ill-fitting shoes it might well aggravate the incidence of musculoskeletal symptoms.

The following figures illustrate the different shapes of feet found in the sample of ward nurses:

Figures 5 & 6.

Short and wide feet.



Figures 7 & 8.

Long and narrow feet.

Figures 9 & 10.

Long and wide feet.

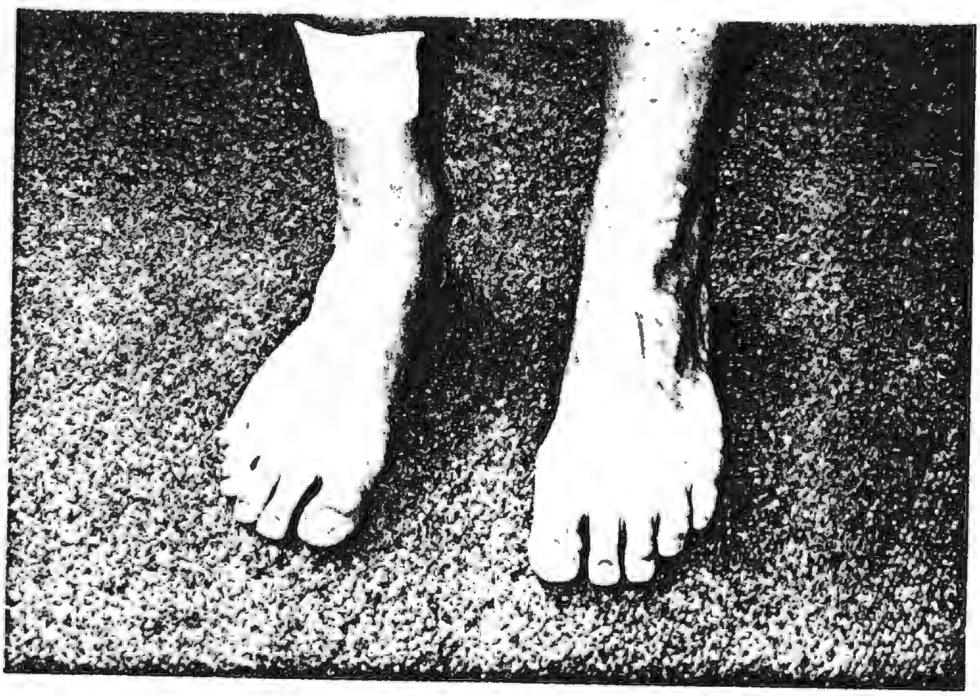


Figure 11.

Very short feet.

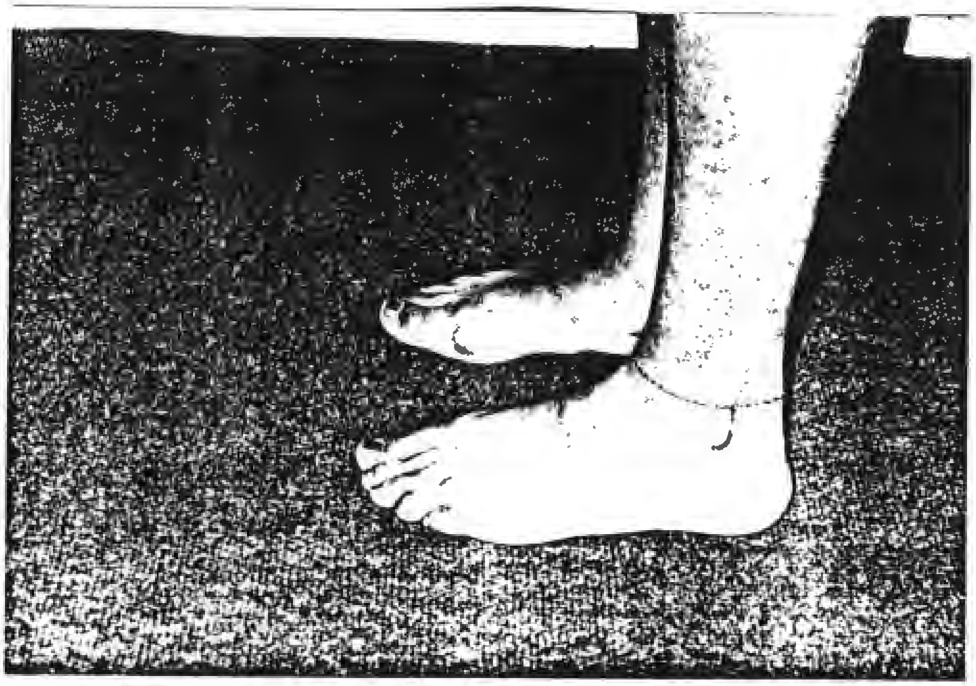
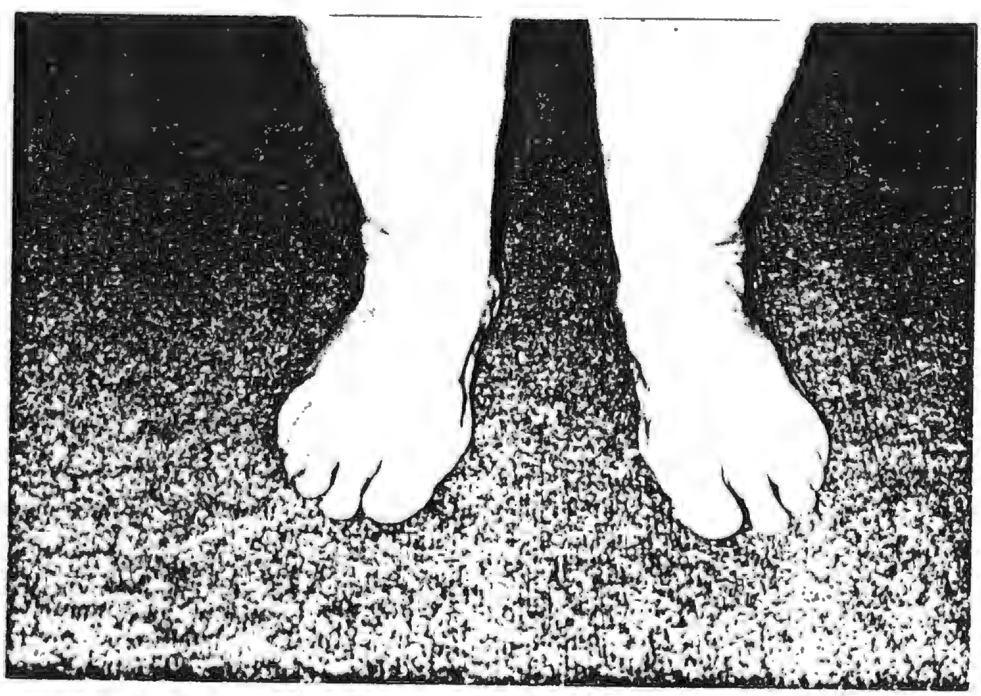


Figure 12.

Very wide feet.



3.2.2 Areas of Pain

In this section of the questionnaire respondents were asked whether they were experiencing pain or discomfort at the time of completing the questionnaire now, or during the past year. In the group of ward nurses, 63% of the respondents complained of lumbar backache during this period. This was followed by cervical / shoulder region pain (41%), painful feet (40%), thoracic backache (31%), pain in the shoulder / arm region (24%), painful legs (23%) and painful hands (8%).

There was no difference between the 2 groups of respondents as far as thoracic back pain, neck/shoulder pain and shoulder/arm pain were concerned. Both groups experienced these pains in a similar fashion. There was, however a difference in the occurrence in the incidence of lower back pain ($p<0.05$), painful hands ($p<0.05$), painful legs ($p<0.05$) and painful feet ($p<0.01$). The ward nurses complained much more about lower back pain (this is well documented in the literature). Ward nurses spend most of their day in the standing position and that would account for the higher incidence of leg and foot pain. The nursing managers complained much more than the ward nurses about painful hands. The nursing managers spend most of their time writing or typing. One can assume that they did not necessarily have training in keyboard skills and that might account for the incidence of painful hands.

There was no difference in the 2 groups of respondents as far as a specific incident causing the pain, or whether non-work-related activities cause the specific complaint ($p>0.05$ in both cases). There was, however a difference in the work-relatedness of the experience of pain. The nursing managers attributed their pain to previous nursing activities.

Once again these finding are evidence of the different stresses and natures of the 2 jobs.

Table 9

The incidence of low back pain.

Lumbar region	Ward Nurses (N=88)
Yes	55
No	31
Did not answer	2

Table 10

Reasons given for the occurrence of low back pain.

Causes of Lumbar Backache	Ward Nurses
Standing	45
Moving patients	41
Flexion (static)	39
Pushing beds	35
Pulling beds	35
Rotation	35
Lifting up heavy equipment	32
Moving furniture	32

The main causes of **lumbar backache** were reported to be standing for long periods of time (51%), followed by moving patients (47%) and static forward flexion (44%). This is consistent with the findings of other researchers. Several studies have concluded that manual lifting and / or moving patients is the main cause for lumbar backache among nursing personnel (Bell 1987, Owen and Garg, 1989 and Stubbs et al. 1983a,b). A further cause for concern is the high levels of postural stress i.e. standing and stooping (Garg et al. 1992). Most of the beds in the hospitals are not height adjustable, therefore ordinary routine nursing tasks are mostly performed in static, fixed and awkward postures i.e. taking a blood sample or passing a catheter. These postures adopted by the nurses during daily routine tasks cause unnecessary postural stress.

In a study done by Wood (1987), it was found that the benefits of a "personnel" programme had a much greater effect on lowering the incidence of lower back injuries than a back training programme.

All the nursing managers attributed their lower back pain to their previous nursing work exposure.

Table 11

The occurrence of thoracic backache.

Thoracic region	Ward Nurses (N=88)
Yes	27
No	56
Did not answer	5

Table 12

Reasons given for the occurrence of thoracic backache.

Causes of Thoracic Backache	Ward Nurses
Flexion and rotation	27
Leaning over patients	25
Opening and closing cylinders	4

All the ward nurses complaining of **thoracic backache** attributed the pain to flexion and rotation and 28% also attributed the pain to fixed, stooped postures for long periods of time. Fixed, awkward postures cause increased postural stress.

The respondents in the nursing manager category attributed their pain to poor seating and poor work station set-up.

Table 13

The occurrence of cervical/shoulder pain.

Cervical / Shoulder region	Ward Nurses (N=88)
Yes	36
No	48
Did not answer	4

Table 14

Reasons given for the occurrence of cervical/shoulder pain.

Causes of cervical/shoulder pain	Ward Nurses
Fixed postures	32
Lifting patients and heavy equipment	27
Stress	17
Fatigue	11
Post mastectomy	1

Thirty six percent of ward nurses complaining of **cervical / shoulder region** pain attributed their pain to sustained fixed postures for long periods of time when tending to patient needs. Lifting and moving patients and / or equipment was the cause for 31% of pain in this region. This might also be an indication of insufficient strength in the upper body region. Stress (19%) and fatigue (13%) also played a big role. Most of the shifts worked by this sample are 12-hour shifts.

As established in the question about working position, the nursing managers mainly sit during their working day and largely perform administrative and VDU based tasks. Hunting et al. (1981) found a higher risk of neck tension syndrome in data entry operators than in general office workers. Significant associations between neck and shoulder symptoms and time spent typing were found by Burt et al. (1990).

It is interesting to note that a much higher percentage of the nursing managers suffer from neck problems (mainly due to their desk-bound activities). A lower percentage of the nursing managers suffer from lower backache, probably due to the fact that they are not exposed to the physical stresses of general ward work.

Table 15

The occurrence of shoulder/arm pain.

Shoulder / Arm region	**Ward Nurses (N=88)**
Yes	21
No	64
Did not answer	3

Table 16

Reasons given for the occurrence of shoulder/arm pain.

Causes of shoulder/arm pain	**Ward Nurses**
Pushing beds	8
Pulling beds	8
Pulling up bed cot sides	7
Picking up babies	3
Post-mastectomy	1

Ten percent of respondents complaining of **shoulder / arm pain** attributed this to pushing and pulling beds; and 8% blamed pulling up the cot-sides of beds. This could possibly be due to the weight of the beds, the friction on the floor surfaces as well as insufficient upper body strength. These tasks are also often performed without assistance. The cot-sides of beds often "stick", causing a sudden jerk movement, which could lead to injuries. Cot-sides are also very difficult to operate without assistance, as most nurses cannot reach and control both ends at the same time.

All the nursing managers contributed their shoulder/arm pain to typing. Sauter et al. (1991) found that relative keyboard height, relative document distance, upper arm angle and hand extension were significantly associated with shoulder and arm discomfort.

In the figures 13 and 14 the nurses are lifting the cotside of the bed. Note the posture of the spine and arms during the performance of this task.

Figure 13

Figure 14

Table 17

The occurrence of hand pain.

Hands	Ward Nurses (N=88)
Yes	7
No	77
Did not answer	4

Table 18

Reasons given for the occurrence of hand pain.

Causes of hand pain	Ward Nurses
Holding objects for a long time	5
Rheumatoid Arthritis	2
Typing	0

Most of the ward nurses complaining of pain in the **hands** attributed this to holding objects for a long time i.e. a needle when inserting an intravenous line, or assisting in an operation and having to hold the suction apparatus for the duration of the procedure.

Most of the nursing managers were probably not trained in typing skills and it may be that their pain is due to poor typing technique as well as inadequate work station set-up.

Table 19

The occurrence of leg pain.

Legs	Ward Nurses (N=88)
Yes	20
No	65
Did not answer	3

Table 20

Reasons given for the occurrence of leg pain.

Causes of leg pain	Ward Nurses
Standing	20
Varicose veins	2

All the respondents complaining of **leg pain** attributed this to the long hours of standing. As mentioned before, nurses in this sample mainly work 12-hour shifts. No nursing managers complained of any leg pain.

Table 21

The occurrence of foot pain.

Feet	Ward Nurses (N=88)
Yes	35
No	50
Did not answer	3

Table 22

Reasons given for the occurrence of foot pain.

Causes of foot pain	Ward Nurses
Standing	25
Walking / Running	21
Stretching up on toes	8
Walking backwards	4
Flat feet	1

Standing (i.e. 71%) was reported to be the cause of most **painful feet**, with running / walking the cause in 60% of cases. The nurses in this sample normally work 8-12 hour shifts. Stretching up onto the toes was the cause for painful feet in 23% of cases. This is indicative of work areas that are too high to reach. All the nurses in this sample were free to choose their own footwear. Ryan (1989) suggests from his study on supermarket workers that standing for long periods of time contribute to among other complaints, ankle and foot pain. He suggests that standing appears to have an effect on foot and ankle symptoms when 50% of working time is spent standing.

Postural stress of the kind that most nurses experience is typically associated with deficiencies in the work station design - particularly with forward reaching over obstacles, working surfaces that are too low and fixed postures maintained for a long period of time (Pheasant,1987).

Table 23

The onset of the pain.

Specific incident giving rise to the pain	**Ward Nurses (N=88)**
Yes	37
No	50
Did not answer	1

Table 24

The work-relatedness of pain.

Specific activity at work causing pain	**Ward Nurses (N=88)**
Yes	68
No	19
Did not answer	1

Table 25

Non-work-related activities causing pain.

Other activities that cause the same pain	**Ward Nurses (N=88)**
Yes	21
No	65
Did not answer	2

Seventy-seven percent of the respondents reported that the pain that they experience is related to activities performed at work, and only 24% of pain experienced is also due to other activities.

3.2.3. Hospital Beds

In this section of the questionnaire, questions were asked about hospital beds to ascertain how user-friendly the design of beds is, generally.

The results about the number of height adjustable beds were not reliable, as most of the ward nurses interviewed were not at all sure and therefore guessed or did not answer at all. The specific number of height adjustable beds at all the institutions is known and this was not reflected in the responses in the questionnaire.

The nursing managers do not work in any wards and ignored this section of the questionnaire.

Table 26

Range of height adjustability of hospital beds.

Sufficient range	**Ward Nurses (N=88)**
Yes	30
No	23
Did not answer	26
Did not know	9

Table 27

Frequency in which hospital beds is adjusted.

How often beds are adjusted	Ward Nurses (N=88)
Always	16
Often	34
Sometimes	10
Rarely	8
Never	3
Did not answer	17

Table 28

The ease/difficulty with which hospital beds can be adjusted.

Ease/difficulty of adjusting beds	Ward Nurses (N=88)
Very difficult	6
Difficult	24
Not so difficult	20
Easy	20
Did not answer	18

Only 34% of the respondents found the range of height adjustable beds sufficient. The desirable height of these beds is dependent on the task to be performed. For patient lifting and / or transfer tasks, an acceptable height should be between knuckle height and standing elbow height. For more delicate tasks, where visual requirements are important, such as passing a catheter or removing stitches from a wound, a level between 50-100 mm above standing elbow height is recommended (Pheasant, 1986; Grandjean, 1988). The elbows should also preferably be supported.

With regard to the frequency with which nurses from the sample actually adjusted the bed for the task that needed to be performed, only 18% of the sample always adjusted the height for the specific task, 39% adjusted the beds often, and 23% adjusted the beds sometimes, rarely or never.

34% of the sample found height adjustable beds difficult or very difficult to adjust, with 44% of the sample found it not so difficult or easy to adjust.

Fixed height beds place severe anthropometric constraints on the nursing staff as far as fixed and stooped postures are concerned. In the United Kingdom the design of hospital beds is subject to the British Standards publication, BS 4886. It requires the height of a fixed height bed to be 610 ± 13 mm. According to BS 5223, spring mattresses should be 160 mm thick and foam mattresses between 100 and 150 mm, depending on the circumstances. (Pheasant, 1987). According to Pheasant (1987), bed height is selected for patient comfort, rather than for nurse safety. The fixed height beds measured in the Western Cape hospitals were 905 mm (compared to the effective working height of around 710 mm in the UK). This working height is only acceptable for the 5th percentile standing elbow height of the Western Cape sample for performing delicate tasks - it is too low for the taller nurses, but again too high for the 5th percentile nurses to perform a lifting or transfer manoeuvre. The delicate tasks could be performed by the taller nurses in the seated position, but it is impossible to get close enough to the patient as it is impossible to get the knees under the bed - when the cot-sides are dropped, there is no space for the knees under the bed.

3.2.4. Equipment

This section of the questionnaire dealt with problems with the physical characteristics of the equipment used on a normal working shift.

There was no difference in the responses of the 2 groups regarding heavy equipment, controls/equipment positioned too high or too low or handles that hurt the hands ($p>0.05$ in all cases). In the case of heavy equipment, the ward nurses reported that EGC machines were too heavy, while the nursing manager group deemed overhead projectors too heavy. The nursing manager group did not give examples of controls/equipment that were too high or too low or of handles that hurt their hands. There was a statistically significant difference between the 2 groups regarding equipment with handles that are too small and equipment that trap the fingers ($p<0.05$ in both cases). In the ward nurses group it was mainly the hospital bed responsible for these problems. These findings once again implicate the working environment and task as cause of problems.

Table 29

Perceived heaviness of portable equipment.

"Portable" equipment too heavy	**Ward Nurses (N=88)**
Yes	35
No	40
Did not answer	9
Did not know	4

Table 30

Examples of equipment that is too heavy.

Examples of heavy equipment	**Ward Nurses**
Beds	17
IV drip stands	12
Drug trolleys	8
Oxygen cylinders	7
CPM machine	7
Image intensifier	6
Defibrillator	4
Arthroscopy unit	2
Suction unit	2
ECG machine	1

Table 31

Controls and/or equipment that are too low for convenience.

Controls/Equipment too low	**Ward Nurses (N=88)**
Yes	21
No	54
Did not answer	8
Did not know	5

Table 32

Examples of equipment/controls that are too low for convenience.

Examples of equipment that is too low	Ward Nurses
Wall plugs under beds	8
Measuring urine on the floor	6
Low level storage areas	4
Lower levels of the trolleys	4

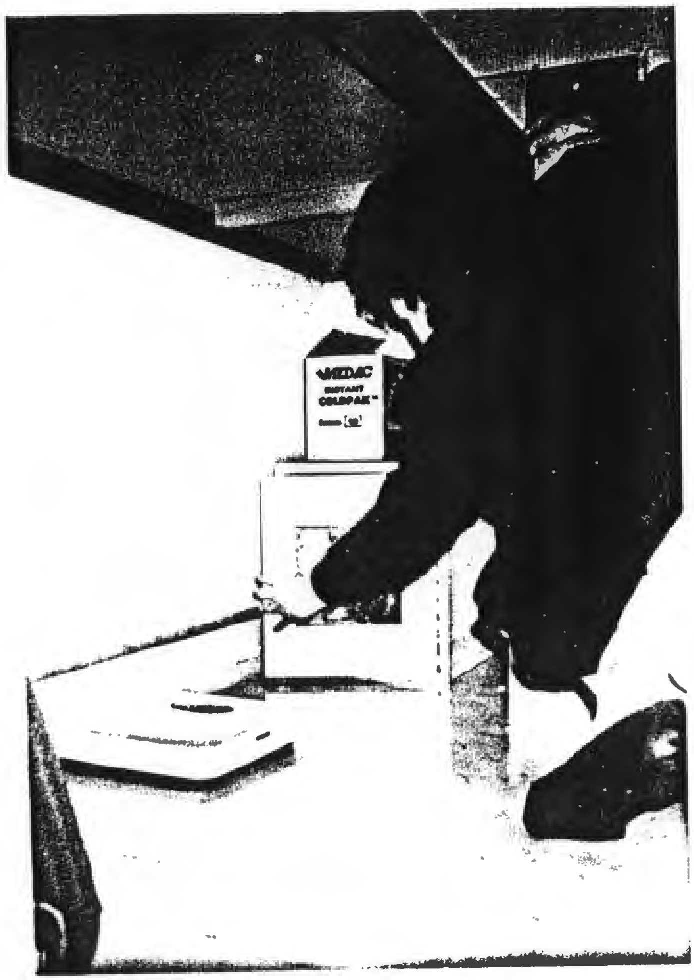
Figure 15.

Figure 15 illustrates the position of the electrical plugs under the beds. This is potentially dangerous, as the nurse can knock her head when stretching under the bed to push the plug into the wall, or when getting up from the floor. This activity can also be dangerous and uncomfortable for nurses with painful joints, e.g. Osteoarthritis sufferers.

Figure 16.

In figure 16 the nurse is emptying the urine bag on the floor. Note the stooped static posture. It would be less strenuous to place the bag-holder on the bedside stool before emptying. Generally a nurse goes on a ward round emptying the urine bags, this means that she adopts this static, stooped posture several times in a relatively short period of time.

Figure 17.



In figure 17 the nurse is trying to operate the emergency electricity supply. The supply box is situated in the corner under the nurses station desk. In order to reach the box, she has to hold onto the desktop for support and balance. She also needs to take care not to knock her head when emerging from under the desk. In this position the box is not easily accessible, particularly in an emergency situation.

Figure 18.

In figure 18 the nurse is bending down to the bottom level of the trolley (height off the floor = 329 mm). As can be seen, poor body mechanics are being applied.

Table 33

Controls/equipment that is too high for convenience.

Too high controls/equipment	**Ward Nurses (N=88)**
Yes	24
No	50
Did not answer	9
Did not know	5

Table 34

Examples given of equipment/controls that are too high for convenience.

Examples of equipment that is too high	**Ward Nurses**
IV drip stands	18
Monitors generally	15
TV shelves	10
Air conditioner controls	7
Oxygen settings	6
Theatre lights	5
Boyles machine	2
Oxygen bank	2

Figure 19.

In figure 19 the nurse is trying to hook the intravenous drip hanger into the ceiling. During observation of this procedure, she only managed to get the hook in on the third attempt. It was achieved by jumping.

This area is a 4-bed high care unit, which means that this task is performed on a fairly regular basis. The nurses also try to hook the drip hanger in before the patient returns from theatre, as it becomes much more difficult when the bed is already in place. Clearly, this is not a satisfactory situation, as it can lead to accidents and potentially serious musculoskeletal injuries. The reason for not using the mobile bedside intravenous drip stand is because of the space constraints in this ward.

Figures 20 & 21.

In figures 20 and 21 two examples of different institutions where the monitors are positioned too high are illustrated. The monitor heights are 1905 mm and 1890 mm respectively. In both cases, this is higher than the 95th percentile stature height (1737 mm) measured in this sample.

Setting and operating these monitors can increase the postural stress, particularly in the cervical and shoulder girdle areas. This is particularly relevant to subjects with vertebral artery conditions, where excessive and prolonged extension can have serious medical consequences.

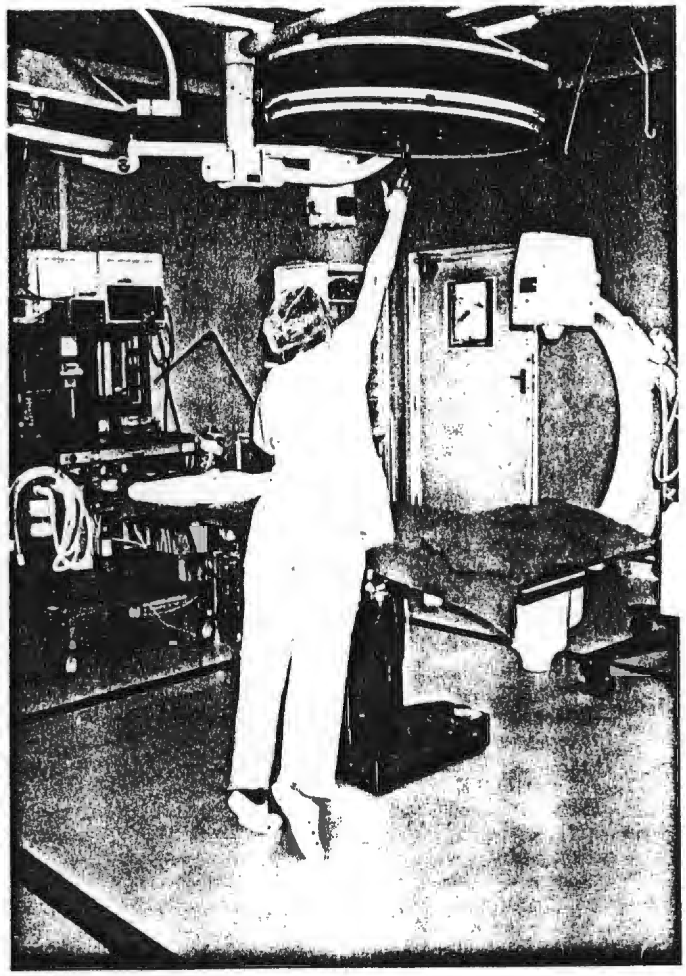
Ideally, these monitors should be on a height adjustable rail.

Figures 22 & 23.

In figures 22 and 23 the height of the television shelf is illustrated. This television shelf is on a bracket 2330 mm off the floor. It is far too high for even the tallest nurse in this sample (1816 mm) to reach.

In figure 23, the nurse is standing on a stool, which should not be stood on. Because of its compressible seat, it is unstable and dangerous to stand on it. She can, however, still barely reach the controls on the television set, even though she is standing on tip toes, which makes the position even more unstable and dangerous. This shelf should not be higher than 1523 mm (5^{th} percentile stature nurse).

Figure 24.



In figure 24 the nurse is attempting to adjust the theatre light. The height of the light is 2150 mm off the floor. The light fitting is also positioned directly above the theatre bed.

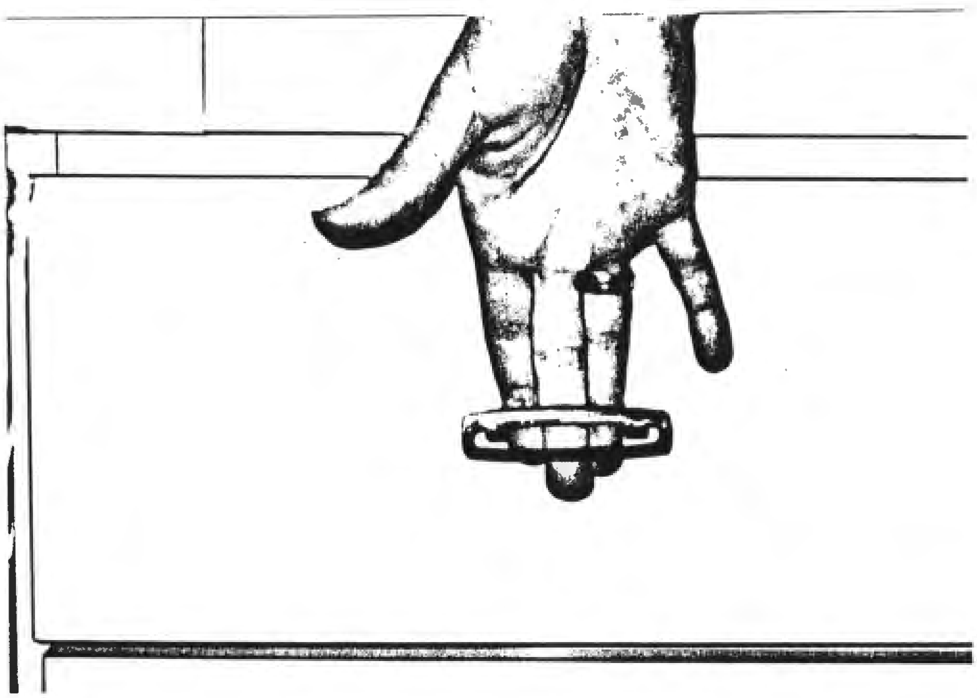
This is a potentially hazardous manoeuvre as it can lead to slipping and falling. This light would be difficult to reach for all the subjects in this sample (the 5th percentile = 1523 mm, and the 95th percentile = 1737 mm).

Table 35

Handles on equipment that are too small.

Too small handles	Ward Nurses (N=88)
Yes	14
No	61
Did not answer	8
Did not know	5

Figure 25.



In figure 25 a handle that is far too small is illustrated. It is not only too narrow, but also to shallow. The handle is totally inappropriate and very difficult to open, especially when the contents are very heavy. This handle was also reported to hurt the nurses' hands (see table 36). In the case of this sample of nurses, handles should be at least 93 mm wide to accommodate the 95th percentile hand breadth.

Table 36

Handles on equipment that hurt the hands.

Handles that hurt the hands	Ward Nurses (N=88)
Yes	27
No	50
Did not answer	7
Did not know	4

Table 37

Examples given of handles that hurt the hands.

Examples of handles on equipment that hurt the hands	Ward Nurses
Bedside handles	27
Portable carts for sterile equipment	9
Spanners on cylinders	5
C-arm and monitors	2
Bedside lockers	1

Table 38

Handles on equipment with moving parts that trap the fingers.

Equipment with moving parts that trap the fingers	Ward Nurses (N=88)
Yes	36
No	40
Did not answer	8
Did not know	4

Table 39

Examples of equipment that trap the fingers.

Examples of equipment that trap the fingers	Ward Nurses
Bedsides	28
Heads of beds	24
Legs of theatre tables	5
Q-cart door	5

Figure 26.

In figure 26 one can see that the nurse's hand is trapped between the cotside and the bed. This due to the cotside often "sticking" and a lot of force is needed to move it. This often results in sudden uncontrollable movement with the hands stuck between the cotside and the bed.

Forty percent of the sample reported that "portable" equipment is too heavy to carry or move around. The main pieces of equipment in question were hospital beds (49%), intravenous drip stands (these were also difficult to push, due to "sticking" wheels over some floor surfaces) (34%), drug trolleys (23%), oxygen cylinders (20%) and Continuous Passive Motion machines (20%). All of the above were also deemed to be uncomfortable shapes to manoeuvre. Most of the time these pieces of equipment are moved or carried by a single nurse on her own.

Twenty-four percent of the sample reported controls and / or equipment to be too low. The situation of wall plugs under the beds at floor level was a problem in both the Leeuwendal as well as the Vincent Palotti hospitals (38%). These are both older buildings and those issues have never been addressed by the management. Measuring urine-output when the bag is on the floor, is also a big problem (29%), as only one nurse normally performs this task, and it is almost impossible to clamp the tube from the patient and measure the output at the same time. Low level storage areas and the lower levels of the trolleys were also considered too low (19%).

Twenty-seven percent of the sample reported controls and / or equipment to be too high. Here the intravenous drip stands (75%) and the position of monitors generally (62%) were deemed the biggest problems. In the Leeuwendal hospital the television shelves were a problem, because of the height of the shelves. The television stand was attached to the wall at a height of 2330 mm. This is obviously way beyond the reach of even the tallest nurse.

Thirty-one percent of the sample reported that they work with equipment that hurt their hands. Here the hospital bed was the problem, 100% reported that the bed-sides hurt their hands when adjusting them. Thirty-three percent reported that the handles of the portable carts for sterile equipment hurt their hands. The grips of the handles were reported to be poorly designed (generally too small).

Forty-one percent of the sample reported that they use equipment with moving parts that trap their fingers. Again the main problem was with the bed sides (68%), and also when adjusting the heads of the beds (59%).

Generally, adjusting the height, the sides as well as the heads of the hospital beds is not an easy task, as the movement is not a smooth one, and some parts always stick, causing an unexpected jerk to the person trying to make the adjustment.

3.2.5. Work Areas

In this section of the questionnaire respondents were asked to comment on the work space in their work areas.

There was no significant difference between the responses of the 2 groups as far as work surfaces that are too high or too low, or seated work spaces with inadequate legroom ($p>0.05$ in all the cases). Both groups reported problems in these areas. There was, however, a statistically significant difference in the responses of the 2 groups as far as work areas that are inadequate for the task to be performed, as well as work areas where one has to reach further than an arm's length ($p<0.05$ in both cases). The ward nurses often have to move the bed to the middle of the room when they have to perform a procedure on the wall side of the hospital bed (space constraints in the wards, see figures 23-29). The nursing managers are generally desk bound and are probably able to a less cluttered office in terms of furniture. In the case of having to stretch further than an arm's length – ward nurses have to do that often due to the poor design of work areas, such as storage spaces (see figure 30). Because of the desk bound nature of the nursing managers, one would assume that they have their required work objects within close range of their desks. These findings prove once again that the design of the task and the work environment play a significant role in the incidence of problems.

Table 40

Reports about inadequate work spaces.

Work areas inadequate for task to be performed	Ward Nurses (N=88)
Yes	50
No	14
Did not answer	24

Table 41

Examples of work areas that are inadequate for the task to be performed.

Examples of work areas that are too small	Ward Nurses
General wards	23
Storage rooms	22
Setting up rooms	8
Gas / Oxygen bank	2
Recovery room	1

Figure 27.

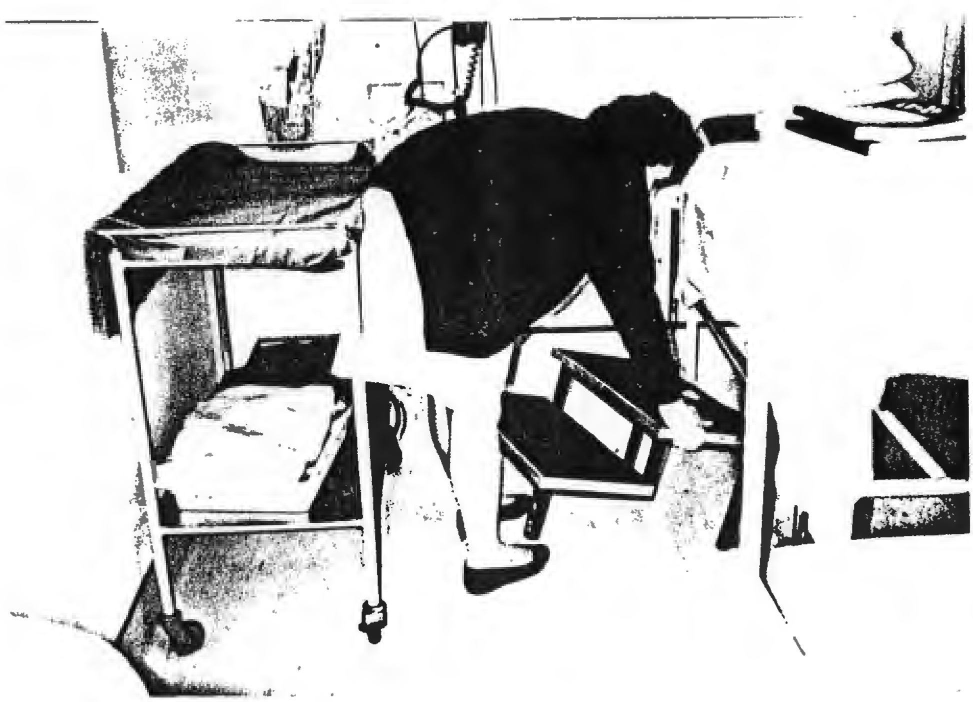


Figure 27 is an example of poor body mechanics, poor manual handling technique and lifting in a confined space.

Figures 28 & 29.

Figures 28 and 29 are examples of inadequate work space. This toilet is totally inaccessible for a wheelchair. There is very little room to perform a patient transfer using the correct body mechanics. The width of this room is 1000 mm and the protrusion of the basin reduces this to 730 mm.

In figure 28 the nurse has to lean over the patient to hang the intravenous drip onto its hook. She has to stabilise herself on the basin with her right hand in order to stretch up on tip toes to reach the hook.

The floor surface is also very slippery which makes the whole situation extremely hazardous.

Toilets should be in an area large enough to accommodate a wheelchair as well as two nurses.

Figure 30.

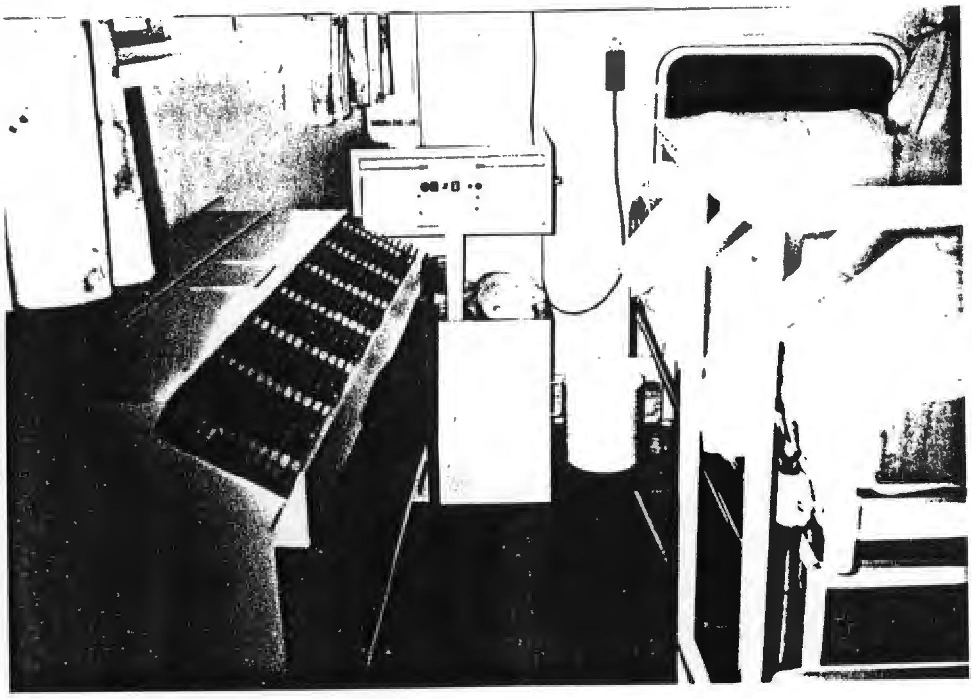


Figure 30 also illustrates a work area where the space is inadequate. The access between the bed and the wall, as well as between the bed and the air-conditioner, is totally inadequate.

The distance between the wall and the bed is 990 mm; and the distance between the air-conditioner and the bed is 380 mm.

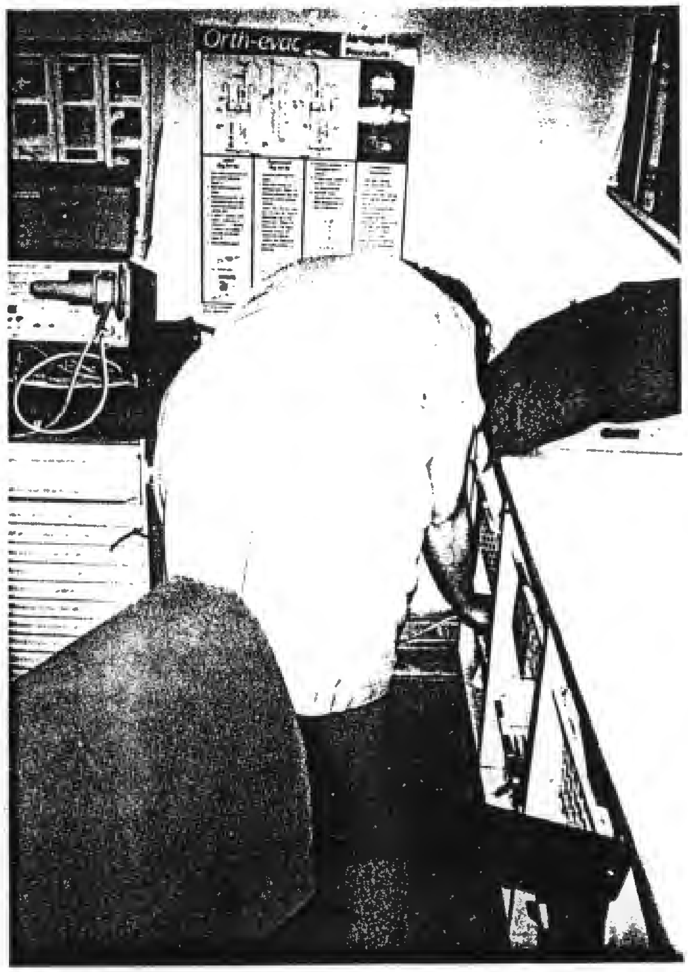
In this confined space it is difficult to perform transfers, or to help a dependant patient to get out of bed, or walk around the bed. There is no space for a wheelchair, commode or trolley between the beds, or between the bed and the wall. In cases where such equipment is needed, the beds have to be moved to accommodate the use of such equipment.

The clearance between beds is 680 mm, which reduces to 340 mm when both the over-bed tables are at the feet of the beds.

Figure 31.

Figure 31 is a clear illustration of the inaccessibility to the bed as discussed in figure 30. The width of the trolley is 460 mm and the length 700 mm. Generally, when the nurses have to perform a task on the wall side of the bed, the bed has to be moved over to the middle of the space between the beds.

Figure 32.



Several mismatches can be observed in figure 32, namely, working in a confined space (the width between the 2 cupboards = 600 mm), storage of emergency supplies in a fairly inaccessible position (280 mm from the floor) and forward stooping (poor body mechanics).

Figure 33.

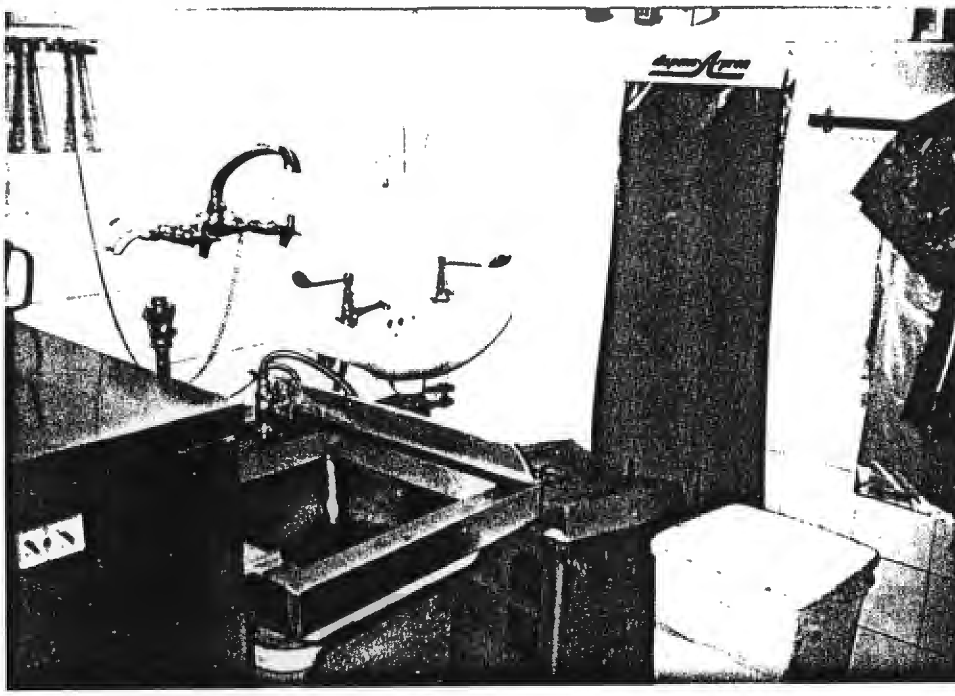


Figure 33 also illustrates an area with inadequate space. To get to the hand basin in the sluice room, one has to lean over the bed pan basin (height off the floor = 725 mm, depth from the wall = 750 mm).

This situation is again potentially hazardous, as this confined area has very limited space to move and place waste containers.

Table 42

Areas where the nurses have to reach further than an arm's length.

Work areas where one has to reach further than an arm's length	Ward Nurses (N=88)
Yes	42
No	16
Did not answer	29
Did not know	1

Figure 34.

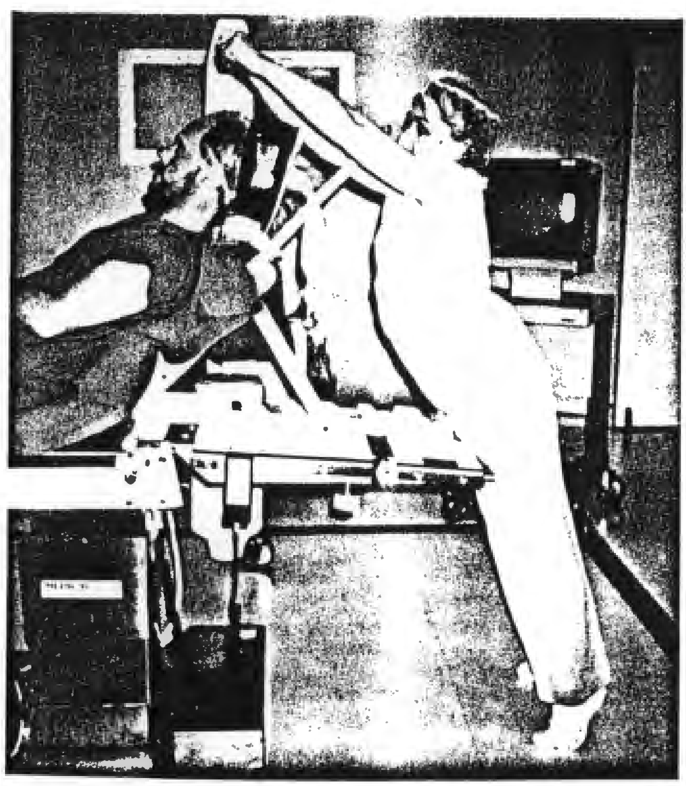


Figure 34 is an illustration of having to reach further than an arm's length. This posture is often adopted by the nurses assisting in a procedure in theatre. This position is maintained for a prolonged period of time, depending on the complexity of the procedure. This enormous and excessive postural loading can lead to various musculo-skeletal conditions. Notice the excessive lumbar lordosis in this posture, as well as the nurse standing on her toes to achieve more height. The theatre table is height adjustable (680 - 1020 mm). This photograph was taken with the table on the lowest setting. The height setting of the table is generally set at a comfortable height for the surgeon performing the operation, rather than that of the nurse.

Table 43

Reports on work surfaces that are too low.

Work surfaces that are too low	Ward Nurses (N=88)
Yes	26
No	37
Did not answer	24
Did not know	1

Table 44

Examples of work areas that are too low.

Examples of work areas that are too low	Ward Nurses
Nurses station desk in high care	26

Figure 35.

In figure 35 the nurse adopts a stooping posture for a prolonged period of time, while measuring the patient's blood pressure. With the patient on a low bed like this, the nurse should rather be sitting on a chair in order to prevent postural loading. In this case, the bed is 560 mm high.

Figure 36.

Figure 36 is also an example of a work surface that is too low. The handles and locks of this medicine trolley are not fixed at the top of the doors. Therefore, in order to open the trolley doors, the nurse has to bend down to reach them. These handles and locks should be attached to the top of the doors. The top of the trolley is also used for writing on the patients' cards and this surface was reported to be too low for writing. The height of the trolley was measured at 800 mm. In order to accommodate the range of nurse in this sample, the height of the trolley should be between 923 mm and 1082 mm (between the 5^{th} and 95^{th} percentiles of standing elbow height).

Table 45

Reports of work surfaces that are too high.

Work surfaces that are too high	Ward Nurses (N=88)
Yes	26
No	38
Did not answer	23
Did not know	1

Table 46

Examples of work surfaces that are too high.

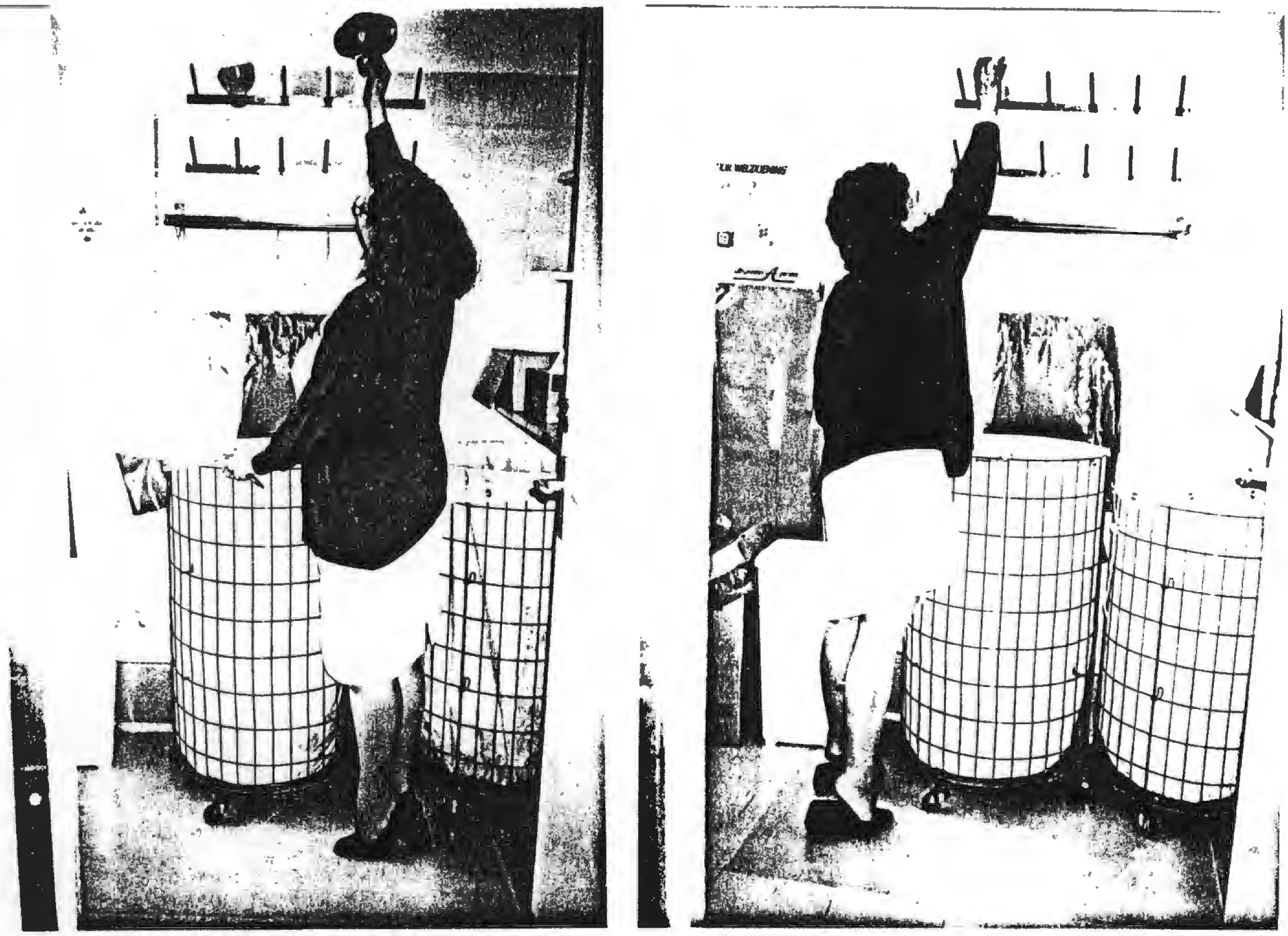
Examples of work areas that are too high	Ward Nurses
Non height adjustable beds	12
Cardiac trolley	5
Pulse monitor	4
Boyles machine	2
Name spaces beside beds	2
Oxygen bank	1

Figures 37 & 38.

Figures 37 and 38 illustrate the problem of the position of the telephone. During very busy times in the ward, the nurses often do not walk around the desk to answer the telephone, but rather stretch to reach the telephone.

In figure 38 it can also be seen that the desk is too high. There is also no foot rest under the desk for the shorter nurses. The desk height is 825 mm, the depth 705 mm and the top ledge 300 mm.

Figures 39 & 40.



Figures 39 and 40 were taken in the sluice room. The height of the bottle storage shelf is 1850 mm. Both nurses are standing on tip toes and they are having to balance on the unstable linen trolley, which has very loose wheels. They are also leaning over the linen trolley (width = 850 mm).

These heights are too high for even the 95th percentile stature in this sample. It is also potentially hazardous to lean on an unstable object for support.

Figure 41.

In figure 41 the storage space is too high (height = 1880 mm). This is too high for even the 95th percentile of stature. The height of the shelving should not exceed 1523 mm in order to accommodate the 5^{th} percentile stature nurses.

The nurse is holding onto the shelf with the right hand to pull herself up to reach the pillows. This is not a stable position and can lead to musculo-skeletal injury. A stable ladder was placed in this storage area (see behind the door), but is not used regularly.

Figures 42, 43 & 44.

In figure 42, the nurse has to reach over the stool to reach the top storage shelf (height = 2015 mm).

In figure 43 she is standing on an unstable stool, which was intended for sitting, not to be stood on. This could prove to be dangerous.

Figure 44 is another example of having to reach and lean over furniture to obtain the required object. She is standing on tip toes and supporting herself on the desk in order to stretch up higher.

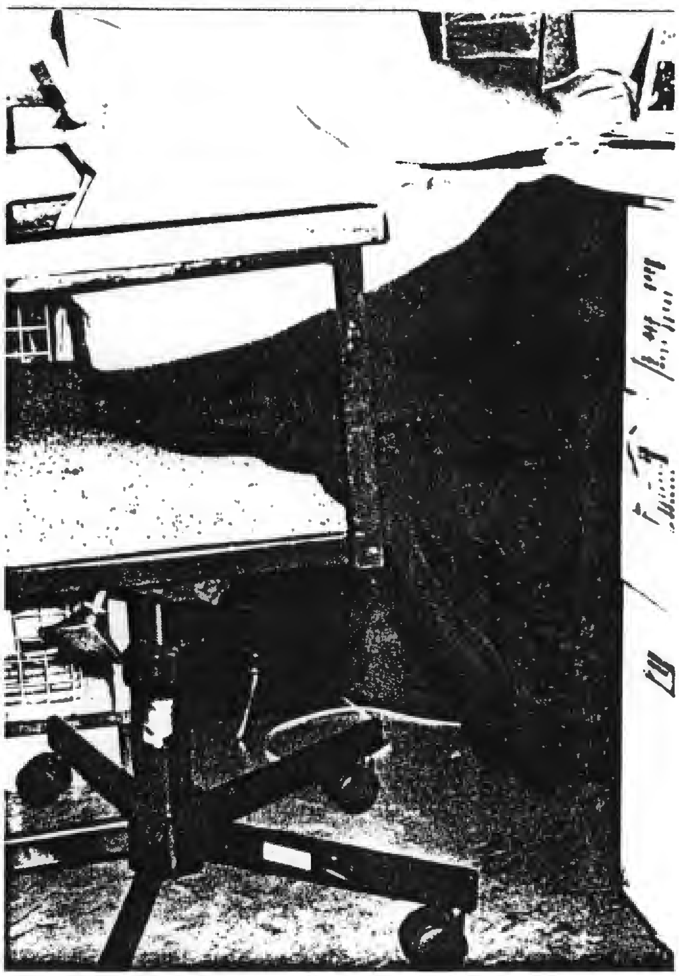
This storage shelf is too high even for the 95th percentile stature nurses.

Table 47

Reports about seated work stations with inadequate legroom.

Seated workspaces with inadequate legroom	**Ward Nurses (N=88)**
Yes	17
No	39
Did not answer	31
Did not know	1

Figure 45.



In figures 45 and 46, there is clearly not enough leg room, mainly because the desks are too low. In photograph 45 the nurse is sitting forward in the chair to accommodate her legs. The height of the underside of this desk is 600 mm.

Figure 46.

In figure 46 the nurse is sitting sideways to accommodate her legs. The underside of this desk is 610 mm. In order to accommodate the 95^{th} percentile user, the underside of the desk should not measure less than 663 mm (popliteal height + thigh clearance).

Fifty-seven percent of the sample reported that the work areas are inadequate for the task to be performed. These were mostly the general wards (wards with up to six beds) (46%) and storage rooms (44%). The lack of space in the ward is critical, particularly when a patient needs to be transferred, and the correct body mechanics cannot be applied by the nurses performing the task. Another problem is that equipment needed for a patient cannot be brought close enough to facilitate easy access to the bed side, e.g. a trolley containing cleaning agents and dressings needed for patient care.

Thirty percent of the sample reported that work surfaces are too low. All those that complained blamed the height of the nurses station desk as being the biggest problem.

Thirty percent of the sample found the non height adjustable beds to be too high. The non-height adjustable beds in the Western Cape hospitals are much higher than the standard set for those in the UK. According to Pheasant (1987), the height of hospital beds are chosen mainly for patient comfort and not for nursing efficiency. Nineteen percent found the height of the trolleys too high, particularly the cardiac trolley, which is mainly used in an emergency. This would place question marks over the efficacy of these nurses in an emergency situation.

3.2.6. Manual Handling

In this section of the questionnaire respondents were asked to comment on their lifting and manual handling activities. Only the ward nurses responded to this part of the questionnaire as the nurse mangers and teachers are not routinely involved in manual handling activities.

Table 48

Lifting activities of the ward nurses.

Lift or move patients	**Ward Nurses (N=88)**
Yes	85
No	2
Did not answer	1

Table 49

Patients lifted with or without help.

Lifting patients alone	Ward Nurses (N=88)
Yes	31
No	54
Did not answer	3

Table 50

The availability of lifting aids.

Availability of lifting aids	Ward Nurses (N=88)
Yes	49
No	32
Did not answer	7

Table 51

The use of lifting aides by the ward nurses.

Use of lifting aids	Ward Nurses (N=88)
Yes	49
No	8
Did not answer	31

Table 52

The usability of the lifting aides.

Usability of aids	Ward Nurses (N=88)
Yes	44
No	4
Did not answer	40

Table 53

The ease of use of the lifting aides.

Ease of operation	Ward Nurses (N=88)
Yes	43
No	6
Did not answer	39

Table 54

Manual handling training by the ward nurses.

Manual Handling techniques training	Ward Nurses (N=88)
Yes	63
No	25

Ninety-seven percent of nurses lift or transfer patients, 35% of whom perform this task alone. Fifty-five percent reported that lifting aids are available, although only 50% of the sample said that they use the aids (mainly draw sheets). Only 50% reported that the aids were usable and only 49% reported that they were easy to use.

The fact that 35% of the respondents lift patients unaided indicates that they are exposed to a very high risk of injury and may be suffering micro-trauma on a regular basis. The new NIOSH guideline for industry states that a maximum of 23 kg may be lifted under ideal conditions. Most lifting in the nursing profession is done under difficult, unexpected and strenuous conditions (Stubbs et al., 1983a). Bell (1987) reported that lifting aides were not regularly used by nurses due to various reasons such as lack of space and difficulty in setting the devices up. Ljungberg et al. (1989) reported that nurses were much more prone to using lifting devices in spacious wards, when the equipment was easy to set up and the patients found the devices user-friendly and comfortable. In the hospitals used in this study, ward space was poorly designed and very cramped. The lifting and moving that these nurses were exposed to was not only related to general nursing care, but also moving furniture around in the wards to gain better access to the patient bed-sides.

Twenty-eight percent of nursing staff had never been trained in manual handling techniques.

Alavosius and Sulzer-Azaroff (1985) and St-Vincent and Tellier (1989) stated that training given in a class room or simulated situation, was not always applied in a real life situation. On the job evaluation of lifting techniques proved to be beneficial in correcting poor technique and may contribute to safer lifting methods.

Stubbs et al. (1983a) reported that lower backache was still regarded as an occupational hazard in nursing. Some lifting is done in an emergency situation where it is not always possible to summon help, or apply correct body mechanics for the manual handling task.

Lifting a patient is not necessarily only overcoming a heavy weight (Bell, 1987). Size, shape, lower limb function, balance, mental competence, physical dependence, co-ordination and co-operation also play a big role. Some patients can be confused or unco-operative and interfere with the lift or transfer. They can also resist movement and/or grab the nursing staff, therefore throwing them off balance. Correct body mechanics can also not always be applied due to problems such as space limitations, equipment and/or patient interference, non-height adjustable beds, chairs and commodes (Garg and Owen, 1992). Harber et al. (1985) added that the shape of the human body is inefficient for lifting and no convenient handholds are available.

Mechanical patient-lifting devices have been available for use in hospitals for at least a century. In a study done by Bell (1987), it was found that very little use is being made of these devices because inter alia, they take too much time, the patients dislike them and the spaces in which they are to be used are too confined. To achieve a systems approach to patient handling equipment, attention must be paid to four variables, i.e., the patient, the attendant, the task and the environment.

The belief held by nurses that back injuries will be prevented if proper lifting techniques and correct body mechanics are used is incorrect. Some patient handling tasks are so stressful that injuries occur even when the circumstances are perceived to be correct (Garg 1991a,b; Stubbs et al. 1983b). Garg (1990) also stated that there is a lack of consensus on proper lifting techniques amongst researchers. There is also no scientific evidence that correct training in manual handling techniques is effective in preventing the incidence of lower backache and injuries. Dehlin et al. (1976) noted that the choice of lifting technique did not affect back pain risk.

In a study conducted by Manuaba et al. (1989) to apply ergonomic principles for enhancing the effectiveness and efficiency of the nursing personnel of both sexes employed at a hospital in Denpasar, Bali, Indonesia, anthropometric, equipment measurements, questionnaires and direct observation were utilised. Both the anthropometric data and direct observation of the nurses and the patient beds generally showed a suitable relationship in respect to posture. The nurses reported no pain, and no complaints were made about the work stations. This was supported by the anthropometric and equipment measurements, as well as by direct observation. The authors concluded that the hospital management had enhanced the efficiency of the nursing personnel through the application of ergonomic principles.

Other researchers (Stubbs et al. 1983a,b, Harber et al. 1985, Ljungberg et al. 1989, Garg et al. 1992 and Hignett 1996a,b) also recommend that an ergonomic approach should be applied to reduce the incidence of lower backache in the nursing environment. The tasks should be designed so that it is within the physical capabilities of the workers. Safer and more efficient methods of handling patients should be applied to reduce the stressful manual handling situations. Ljungberg et al. (1989) found that less injuries were reported by nursing staff that work in modern, spacious wards, than by nurses working in older, poorly designed wards. Nurses were also more likely to use the more modern, easy to use hoists in more spacious environments.

In their conclusions, Garg and Owen (1992) reported that the back injury rate reduced significantly after ergonomic intervention was introduced into 2 units in a large nursing home (47 per 200 000 work-hours, compared to 83 before intervention).

3.3. Tests of Association

In this section the results of the tests of association are presented. These tests were carried out to ascertain whether the problems the nurses reported were randomly distributed across the anthropometric range or whether there was an association with body size measurements. If associated with body size measurements, this would have important implications in the design of nursing and hospital care facilities.

Table 55 summarises the anthropometric dimensions that were tested for an association with equipment problems and musculoskeletal pain.

Table 55

Summary of the problems analysed.

Potential Problem	**Dimensions Tested**
1. Problems reaching work objects	Grip reach, Stature & Standing shoulder height
2. Problems buying clothes in a shop	Stature & Hip width
3. Problems buying shoes in a shop	Foot length and Foot breadth
4. Lower Backache	Stature, Abdominal depth, Length of service, Age & Trunk length
5.Thoracic Backache	Stature, Trunk length & Length of service
6. Neck/shoulder pain	Stature, Standing shoulder height & Length of service
7. Shoulder/arm pain	Stature, Grip reach, Standing shoulder height & Length of service
8. Leg pain	Hours standing per day & Length of service
9. Hospital beds easy/difficult to adjust	Hand Length, Hand breadth & Body Mass Index
10. "Portable" equipment too heavy	Stature & Body Mass Index
11. Controls/equipment too low for convenience	Stature & Standing shoulder height
12. Controls/equipment too high for convenience	Stature & Standing shoulder height
13. Handles on equipment	Hand length, Palm length & Hand breadth
14. Handles that cause pain	Hand length, Palm length & Hand breadth
15. Equipment with moving parts that trap the fingers	Hand length, Palm length & Hand breadth
16. Work areas with inadequate space for the task to be performed	Stature & Body Mass Index

Table 55 cont.

17. Low work surfaces that	Stature & Standing elbow height
18. High work surfaces	Stature & Standing elbow height
19. Seated work spaces with inadequate legroom	Popliteal height, Buttock-knee length & Thigh clearance

The anthropometric dimensions were divided into four categories corresponding to the first, second, third and fourth quartiles to comply with the constraints of the statistical procedure. Too many categories (e.g. deciles) would have resulted in the expected frequencies being too low and would then have had to be combined as discussed in the following section.

The frequencies of occurrence of the main musculoskeletal and usability problems were counted for each quartile and cast into contingency tables with respect to the anthropometric dimensions. For example, when testing for an association between grip reach and problems reaching work objects, a contingency table was set up with subtotals for the first, second, third and fourth quartile statures, divided into those who reported having problems reaching for work objects, those who did not, and those who did not answer. For grip reach, 38 out of 88 respondents reported problems reaching for work objects, 47 reported that there were no problems and 3 did not reply. Twenty of those who reported problems were in the 1st quartile for grip reach. Only 2 respondents in the first quartile reported that they had no problems. Similarly, only 5 of the 26 respondents in the 4th quartile for grip reach reported problems reaching for work objects. Twenty reported that they had no problems.

The chi-square test was used to determine whether there was an association between the presence of problems and the anthropometry of the users. The null hypothesis was that the frequency of occurrence of any problems would be independent of the anthropometry of the nurses (i.e. that the proportions of nurses experiencing problems would be the same in the four quartiles).

3.3.1. Assumptions of the chi-squared test

According to Siegel (1956) no more than 20% of the expected frequencies should be below 5. If more than 20% of the expected frequencies are below 5, Siegel recommends that the researcher combines the adjacent categories in a meaningful way, and that this process be continued until fewer than 20% of the cells have an expected frequency of less than 5, and that no cell has an expected frequency less than 1.

3.3.2. Constraints on the Interpretation of the Findings

Many anthropometric dimensions are highly correlated with each other (see correlation matrix on page 51). Therefore one would expect some of the associations to be statistically significant, by chance. For example, if Stature is associated with a specific problem, one would expect that the dimensions that correlate highly with Stature will also have statistically significant associations with the same problem. Thus, it would be inappropriate to make strong statements about the meaning of any particular associations. Rather, the findings are offered as evidence that many of the problems reported by the nurses are related to body size variability rather than being general usability problems that affect all nurses irrespective of their physical size.

3.3.3. Example

Problems of reaching work objects

The anthropometric dimensions tested were Grip reach and Stature.

Anthropometric dimension: **Grip reach**

Table 56

Distribution of reach problems with respect to grip reach in the sample.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	20	10	3	5
No	2	10	15	20
No response	1	1	0	1

Table 57

In table 57 the observed and expected frequencies are presented.

Observed Frequency	Expected Frequency
20	9.93
10	9.07
3	7.78
5	11.23
2	12.28
10	11.22
15	9.61
20	13.89
1	0.78
1	0.72
0	0.61
1	0.89

Anthropometric dimension**: Stature**

Table 58

Distribution of reach problems with regard to stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	19	10	7	2
No	4	16	10	17
No response	1	1	0	1

Table 59

In table 59 the observed and expected frequencies are presented.

Observed Frequency	Expected Frequency
19	10.52
10	11.83
7	7.45
2	9.20
4	12.67
16	14.26
10	9.00
17	11.09
1	0.81
1	0.91
0	0.57
1	0.71

In both the above cases, more than 20% of the expected frequencies were less than 5. In both cases the categories No and No response categories were combined in the following manner:

Anthropometric dimension: **Grip reach**

Table 60

In table 60 the collapsed version of table 56 is presented.

	1st Quartile	**2^{nd} Quartile**	**3rd Quartile**	**4th Quartile**
Yes	20	10	3	5
No & No response	3	11	15	21

Table 61

In table 61 the observed and expected frequencies of table 60 are presented.

Observed Frequency	**Expected Frequency**
20	9.93
10	9.07
3	7.77
5	11.23
3	13.07
11	11.93
15	10.23
21	14.77

There was a statistically significant association between Grip reach and problems reaching objects at work (Chi-squared = 29.37, $p < 0.01$, df = 3). For grip reach, 38 out of 88 respondents reported problems reaching for work objects and 50 reported that there were no problems. Twenty of those who reported problems were in the 1st quartile for grip reach. Only 2 respondents in the first quartile reported that they had no problems. Similarly, only 5 of the 26 respondents in the 4th quartile for grip reach reported problems reaching for work objects. Twenty reported that they had no problems.

Anthropometric dimension: **Stature**

Table 62

In table 62 the collapsed version of table 58 is presented.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	19	10	7	2
No & No response	5	17	10	18

Table 63

In table 63 the observed and expected frequencies of table 62 are presented.

Observed Frequency	Expected Frequency
19	10.52
10	11.83
7	7.45
2	9.20
5	13.48
17	15.17
10	9.55
18	11.80

There was a statistically significant association between Stature and problems reaching objects at work (Chi-squared = 20.17, $p < 0.01$, df = 3). Thirty eight out of 88 respondents reported problems reaching for work objects and 47 reported that there were no problems. Nineteen of those who reported problems were in the first quartile for stature. Only 4 respondents in the first quartile reported that they had no problems. Similarly, only 2 of the 20 respondents in the fourth quartile for stature reported experiencing problems reaching for work objects. Seventeen reported that they had no problems.

Anthropometric dimension: **Standing Shoulder Height**

Table 64

Distribution of reach problems with regard to standing shoulder height.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	20	11	3	4
No & No response	4	8	19	19

There was a statistically significant association between Standing shoulder height and problems reaching objects at work (Chi-squared = 33.08, $p < 0.01$, df = 3). For standing shoulder height, 38 out of 88 respondents reported problems reaching for work objects and 50 reported that there were no problems. Twenty of those who reported problems were in the 1st quartile for standing shoulder height. Only 4 respondents in the first quartile reported that they had no problems. Similarly, only 4 of the 23 respondents in the 4th quartile for standing shoulder height reported problems reaching for work objects. Nineteen reported that they had no problems.

Clearly, grip reach, stature and standing shoulder height are anthropometric measurements that place constraints on the design of those parts of the hospital environment with which nurses interact. Ideally, the 5th percentile grip reach (at shoulder height) of nurses should be used to specify maximum heights and depths of storage spaces and shelves to ensure that small nurses do not have problems reaching for work objects. In the hospitals and clinics studied, it appears that this had not been done.

In the case of this study the 5th percentile grip reach of the nurses measured is 623 mm and the 5^{th} percentile standing shoulder height, 1259 mm.

This mismatch in design might also have implications on the pain and discomfort of the nurses as 41% of the respondents complained of cervical/shoulder region pain, and 24% of the respondents complained of shoulder/arm pain.

The contingency tables which follow have been collapsed where necessary to accommodate the above mentioned constraints on the use of the Chi-squared test (Siegel, 1956). The original tables are presented in appendix 2.

3.3.4. Problems buying clothes in a shop

The anthropometric dimensions tested were Stature and Hip width.

In the case of both dimensions tested, more than 20% of the expected frequencies were less than 5. In both cases the categories No and No response were combined in the following manner:

Anthropometric dimension: **Stature**

Table 65

Problems buying clothes related to the distribution of stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	9	7	3	7
No & No response	17	20	9	16

There was no statistically significant association between Stature and buying clothes in a shop (Chi-squared = 0.77, $p > 0.05$, df = 3). Twenty six of the respondents reported problems buying clothes. The distribution of those reporting problems were fairly evenly distributed amongst the four quartiles as far as the stature measurement was concerned.

Anthropometric dimensions: **Hip width**

Table 66

Problems buying clothes related to the distribution of hip width.

	Ist Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	4	1	2	19
No & No response	18	29	15	0

There was a statistically significant association between Hip width and problems buying clothes in a shop (Chi-squared = 53.29, $p< 0.01$, df = 3). Twenty six out of 88 respondents reported problems buying clothes in a shop and 61 reported that there were no problems. Nineteen of those that reported problems were in the fourth quartile for hip width. Five out of 23 respondents with hip width measurements in the first quartile reported problems buying clothes. Not one respondent with her hip width measurement in the fourth quartile reported problems. Only 2 respondents with hip width measurements in the second and third quartiles reported problems buying clothes in a shop. It is therefore clear that the problem lies with subjects with wide hips. This is perhaps also indicative of being overweight. At present it does not seem that clothes designers take hip width measurements into account when designing clothes for general distribution. Nurses specifically need clothes that are loose fitting enough to allow them to bend and move around comfortably and unrestricted.

Figure 47.

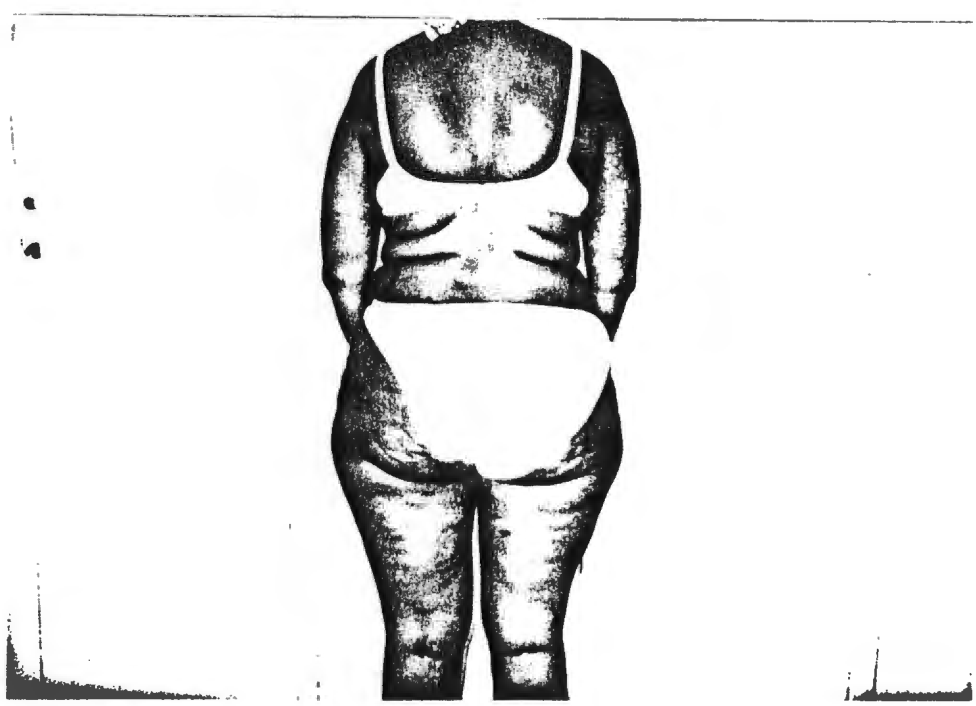


Figure 47 is an example of a large hip width.

3.3.5. Problems buying shoes in a shop

The anthropometric dimensions measured were Foot length and Foot breadth.

In the case of both the dimensions tested, more than 20% of the expected frequencies were less than 5. In both cases the categories No and No response were combined in the following manner:

Anthropometric dimension: **Foot length**

Table 67

Problems buying shoes related to the distribution of foot length.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	12	2	7	13
No & No response	7	27	20	0

There was a statistically significant association between Foot length and problems buying shoes in a shop (Chi-squared = 39.63, $p < 0.01$, df = 3). Thirty four out of 88 respondents reported problems when buying shoes in a shop and 53 reported that there were no problems. Twelve of those who reported problems were in the first quartile for foot length, and 13 of those who reported problems were in the fourth quartile for foot length. All the respondents with foot length measurements in the 4th quartile had problems buying shoes. This is perhaps indicates that the range of shoe sizes available in South Africa is not wide enough. To be able to accommodate 90% of the user population, shoes sizes should include foot lengths of between 216 mm and 269 mm inclusive (5th and 95th percentiles, respectively). Few subjects with foot length measurements in the second and third quartiles reported problems.

Anthropometric dimension: **Foot breadth**

Table 68

Problems buying shoes related to the distribution of foot breadth.

	1st Quartile	2^{nd} Quartile	3rd Quartile	4th Quartile
Yes	11	0	5	18
No & No response	4	27	22	1

There was a statistically significant association between Foot breadth and problems buying shoes in a shop (Chi-squared = 54.45, $p < 0.01$, df = 3). Thirty four out of 88 respondents reported problems buying shoes and 53 reported that there were no problems. Eighteen of those who reported problems were in the fourth quartile for foot breadth and 11 were in the first quartile for foot breadth. Only one respondent out of 19 with the foot breadth measurement in the 4^{th} quartile reported no problems. Once again, this also indicates that the range of shoe sizes available in South Africa is not wide enough. To be able to accommodate 90% of the user population, shoes sizes should include foot widths of between 76 mm and 114 mm inclusive (5^{th} and 95^{th} percentiles, respectively). Very few subjects with foot breadth measurements in the second and third quartiles for foot breadth reported problems.

As can be seen from the above, subjects at both extremes are having problems, i.e. subjects with very short or very long feet, and/or subjects with very narrow or very wide feet. Only 60% of respondents are accommodated when shopping for shoes. This is also indicative of the extreme shapes present in this sample and perhaps as well as the fact that many locally produced shoes are made from imported lasts.

Nurses stand for most of their working time and would therefore need very comfortable shoes for this purpose. There is also an obvious connection between the problems buying comfortable shoes and foot pain in the nursing profession as the strong association suggests. Forty percent of the respondents in this sample reported foot pain and 23% leg pain. In both cases standing was reported to be the biggest cause for their pain and discomfort. Ryan (1989) suggests from his study on supermarket workers that standing for long periods of time contribute to among other complaints, to ankle and foot pain. He suggests that standing appears to have an effect on foot and ankle symptoms when 50% of working time is spent standing. The respondents in this sample reported that they stand for most of their working shifts. The shifts generally range from 8 – 12 hours. See figures 5-12 (pages 56-59).

3.3.6. Lower backache

The dimensions tested were Stature, Abdominal depth, Length of service, Age and Trunk length. Fifty-five out of 88 respondents (representing 63% of the sample) reported suffering from lower backache and 33 reported that they did not suffer from lower backache.

In all the above cases, except in the case of Length of service, more than 20% of the expected frequencies were less than 5. In all cases the categories No and No response were combined in the following manner:

Anthropometric dimension: **Stature**

Table 69

Distribution of lower backache with respect to stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	5	15	19	16
No & No response	13	10	5	5

There was a statistically significant association between Stature and lumbar backache (Chi-squared = 13.85, $p < 0.01$, df = 3). Only 5 out of 18 respondents with stature measurements in the 1st quartile reported lower backache. Thirteen in the 1st quartile for stature did not suffer from lower backache. Thirty five respondents who complained of backache were in the 3rd and 4th quartiles and only 10 respondents in the 3rd and 4th quartiles did not complain of lower backache. This association is consistent with the findings of Heliövaara (1987) that stature is considered a significant predictor of lumbar disc herniation. This is also consistent with the findings of Li (1992) and Mital et al. (1993) that stature is indeed considered a risk factor for lower backache in manual handling tasks. Manual handling has also been recognised by many researchers (Bell

1987, Owen and Garg, 1989 and Stubbs et al., 1983a,b) to be the main cause for lumbar backache in nursing. However, not all researchers have found stature to be related to the incidence of lower backache (Biering-Sørensen, 1984, Pope et al., 1985).

Anthropometric dimension: **Abdominal depth**

Table 70

The distribution of lower backache with respect to abdominal depth.

	1st Quartile	**2nd Quartile**	**3rd Quartile**	**4th Quartile**
Yes	0	24	16	15
No & No response	15	9	5	4

There was a statistically significant association between Abdominal depth and lumbar backache (Chi-squared = 30.35, $p < 0.01$, df = 3). No respondents complaining of lower backache were in the 1st quartile and only 4 in the 4th quartile responded that they did not suffer from lower backache. All 55 respondents complaining of lower backache were in the 2nd, 3rd and 4th quartiles, with 18 respondents in the same quartiles with no lower backache. The 15 respondents with abdominal depth measurements in the 1st quartile did not report lumbar backache.

Subjects with deeper abdomens (figure 48) seem to be more prone to lumbar backache. Abdominal depth is a measure of obesity. Fuortes et al. (1994) conclude in their study that being overweight is an increasingly significant risk factor in lower backache.

Figure 48.

Figure 48 is an example of large abdominal depth.

Variable: **Age**

Table 71

The distribution of lower backache with respect to age.

	< 33 Years	33-39 Years	39-46 Years	>46 Years
Yes	15	13	10	17
No & No response	10	10	11	2

There was no statistically significant association between Lower backache and Age (Chi-squared = 7.55, $p > 0.05$, df = 3). It is interesting that the proportion of lower backache is higher in the 1st and 4th quartiles. This might be explained by the "healthy worker effect". Last (1988) defines the "healthy worker effect" as primarily, that the fittest, healthiest workers are selected, or secondarily, that the workers who become ill or injured, leave the work force.

Variable: **Length of Service**

Table 72

The distribution of lower backache with respect to length of service.

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	8	11	16	20
No	13	5	7	8

There was no statistically significant association between lower backache and Length of service (Chi-squared = 7.05, $p > 0.05$, df = 3). Dehlin et al. (1976) found no relation between length of service and low back pain.

Anthropometric Dimension: **Trunk Length**

Table 73

The distribution of lower backache with respect to trunk length.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	12	11	16	16
No & No response	7	10	7	9

There was no statistically significant association between lower backache and Trunk length (Chi-squared = 1.43, $p > 0.05$, df = 3).

3.3.7. Thoracic backache

The dimensions measured were Stature, Trunk length and Length of service.

In the case of Stature, more than 20% of the expected frequencies were lower than 5. It was further analysed by combining the No and No response cells in the following manner:

Anthropometric dimension: **Stature**

Table 74

The distribution of thoracic backache with respect to stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	5	6	9	7
No & No response	15	14	15	17

There was no statistically significant association between Stature and Thoracic backache (Chi-squared = 0.86, $p > 0.05$, df = 3).

Anthropometric dimension: **Trunk Length**

Table 75

The distribution of thoracic backache with respect to trunk length.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	7	8	5	9
No & No response	17	16	13	15

There was no statistically significant association between Trunk length and Thoracic backache (Chi-squared = 0.06, $p > 0.05$, df = 3).

Variable: **Length of Service**

Table 76

The distribution of thoracic backache with respect to length of service.

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	5	7	7	8
No	11	17	16	17

There was no statistically significant association between Thoracic backache and Length of service (Chi-squared = 0.049, $p > 0.05$, df = 3).

3.3.8. Neck / Shoulder pain

The dimensions tested were Stature, Standing shoulder height and Length of service.

In the case of Stature and standing shoulder height, more than 20% of the expected frequencies were lower than 5. It was further analysed by combining the No and No response cells in the following manner:

Anthropometric dimension: **Stature**

Table 77

The distribution of neck/shoulder pain with respect to stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	15	12	5	4
No & No response	8	12	16	16

There was a statistically significant association between Stature and Neck / Shoulder pain (Chi-squared = 12.6, $p < 0.01$, df = 3). Thirty-six out of 88 respondents reported neck/shoulder pain and 52 reported no pain. Fifteen of those who reported problems were in the 1st quartile for stature. Only 8 respondents in the 1st quartile reported that they had no pain. Similarly, only 4 of the 20 respondents in the 4th quartile for stature experienced neck/shoulder pain. Sixteen respondents reported that they had no problems.

Anthropometric dimension: **Standing shoulder height**

Table 78

The distribution of neck/shoulder pain with respect to standing shoulder height.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	16	13	4	3
No & No response	9	12	13	18

There was a statistically significant association between Standing shoulder height and Neck / Shoulder pain (Chi-squared = 15.07, $p < 0.01$, df = 3). Thirty-six out of 88 respondents reported neck/shoulder pain and 52 reported no pain. Sixteen of those who reported problems were in the 1st quartile for standing shoulder height. Only 9 respondents in the 1st quartile reported that they had no pain. Similarly, only 3 of the 20 respondents in the 4th quartile for stature experienced neck/shoulder pain. Eighteen respondents reported that they had no problems.

This finding indicates that it is the shorter nurses who are experiencing the problems. This might also suggest that shorter nurses are not as strong and more at risk of shoulder girdle injury when carrying out manual handling tasks. Stature and standing shoulder height are again implicated as anthropometric measurements which place constraints on the design of heights of storage spaces. Ideally, the maximum acceptable heights of shelves should be specified by using the 5th percentile standing shoulder height of nurses to ensure that the shorter nurses can reach these areas with ease. In the case of this study, the 5th percentile standing shoulder height of nurses is 1259 mm. It appears that in the facilities where the measurements were taken, anthropometric data were not used to specify the designs.

Variable: **Length of service**

Table 79

The distribution of neck/shoulder pain with respect to length of service.

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	7	8	9	12
No	15	11	12	14

There was no statistically significant association between Neck / Shoulder pain and Length of service (Chi-squared = 1.09, $p > 0.05$, df = 3). Length of employment and age were shown to be significant in medical secretaries (Kamwendo et al., 1991a).

3.3.7. Shoulder / Arm pain

The dimensions tested were Stature, Standing shoulder height, Grip reach and Length of service.

In the cases of Stature, Standing shoulder height and Grip reach more than 20% of the expected frequencies were below 5. In both cases the No and No response cells were combined in the following manner:

Anthropometric dimension: **Stature**

Table 80

The distribution of shoulder/arm pain with respect to stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	5	4	2
No & No response	8	16	18	25

There was a statistically significant association between Stature and Shoulder / Arm pain (Chi-squared = 14.37, $p < 0.01$, df = 3). Twenty-one of the 88 respondents reported shoulder/arm pain and 67 reported that there were no problems. Ten of those who reported problems were in the 1st quartile for stature. Only 8 respondents in the 1st quartile reported that they had no problems. Similarly, only 2 out of 27 respondents in the 4th quartile for stature reported shoulder/arm pain. Twenty-five respondents reported that they had no shoulder/arm pain. It is clear that it is the shorter people who have most of the problems.

Anthropometric dimension: **Standing Shoulder Height**

Table 81

The distribution of shoulder/arm pain with respect to standing shoulder height.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	11	6	3	1
No & No response	7	16	19	25

There was a statistically significant association between Standing shoulder height and Shoulder / Arm pain (Chi-squared = 20.89, $p < 0.01$, df = 3). Twenty-one of the 88 respondents reported shoulder/arm pain and 67 reported that there were no problems. Eleven of those who reported problems were in the 1st quartile for standing shoulder height. Only 7 respondents in the 1st quartile reported that they had no problems. Similarly, only 1 out of 26 respondents in the 4th quartile for standing shoulder height reported shoulder/arm pain. Twenty-five respondents reported that they had no shoulder/arm pain. It is clear that it is the shorter people who have most of the problems. Having to stretch up so high on a regular basis puts much more load on the shoulder girdle and neck muscles. This exposes these nurses to micro-trauma on a regular basis.

Stature and standing shoulder height are clearly anthropometric dimensions which place constraints on the design of heights of storage spaces. Ideally, the maximum acceptable heights of shelves should be specified by using the 5th percentile standing shoulder height of nurses to ensure that the shorter nurses can reach these areas with ease. This would prevent the shorter nurses from having to stretch up unduly. In the case of this study the 5th percentile standing shoulder height is 1259 mm and the 5th percentile stature, 1523 mm. It appears that in the facilities where the measurements were taken, anthropometric data were not used to specify the designs.

Anthropometric dimension: **Grip reach**

Table 82

The distribution of shoulder/arm pain with respect to grip reach.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	17	1	2	1
No & No response	6	14	22	25

There was a statistically significant association between Grip reach and Shoulder / Arm pain (Chi-squared = 43.07, $p < 0.01$, df = 3). Twenty-one out of the 88 respondents reported problems with shoulder/arm pain and 67 reported that there were no problems. Seventeen of those who reported problems were in the 1st quartile for grip reach. Only 1 respondent with grip reach measurement in the 4th quartile reported pain. Similarly, 6 out of 67 and 25 out of 67 who reported no problems were in the 1st and 4th quartiles, respectively, for grip reach.

Clearly, grip reach is also an anthropometric measurement that places constraints on the design of those parts of the hospital environment with which nurses interact. Ideally, the 5th percentile grip reach of nurses should be used to specify maximum heights and depths of storage spaces and shelves to ensure that small nurses do not have problems reaching for work objects. In the hospitals and clinics studied, it appears that this had not been done.

In the case of this study the 5th percentile grip reach of the nurses measured is 623 mm. Ideally, the depth of storage shelves should not be more than 623 mm. This will enable the smaller nurses to have better and more comfortable access in those areas in the work place. See figures 13 & 14 (pages 64 and 65).

Variable: **Length of Service**

Table 83

The distribution of shoulder/arm pain with respect to length of service.

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	6	3	3	9
No	16	18	16	17

There was no statistically significant association between Shoulder / Arm pain and Length of service (Chi-squared = 3.54, $p > 0.05$, df = 3). There was also no statistically significant association between Hand pain and Length of service (Chi-squared = 2.39, $p > 0.05$).

3.3.10. Painful legs

The variables tested were Hours standing per day and Length of service.

In the case of Time spent standing more than 20% of the expected frequencies were below 5. In this case the No and No response cells were combined in the following manner:

Variable: **Hours standing per day**

Table 84

The distribution of leg pain with respect to hours standing per day.

	4-6 Hours	6-8 Hours	8-10 Hours	10-12 Hours
Yes	6	2	5	7
No & No response	18	18	15	17

There was no statistically significant association between Leg pain and time spent standing (Chi-squared = 2.54, $p > 0.05$, df = 3).

Variable: **Length of Service**

Table 85

The distribution of leg pain with respect to length of service.

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	3	6	5	6
No	15	16	18	19

There was no statistically significant association between Leg pain and Length of service (Chi-squared = 0.67, $p > 0.05$). There was also no statistically significant association between Foot pain and Length of service (Chi-squared = 0.70, $p > 0.05$).

3.3.11. Ease/difficulty of adjusting hospital beds

The dimensions tested were Hand length, Hand breadth and Body Mass Index.

In all the above cases more than 20% of the expected frequencies were below 5. In all 3 cases the Very difficult and Difficult cells, and the Not so difficult and Easy cells were combined in the following manner:

Anthropometric dimension: **Hand length**

Table 86

The distribution of ease of adjusting hospital beds with respect to hand length.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Very difficult & Difficult	7	3	8	10
Not so difficult & Easy	8	16	10	8
No Response	5	3	5	5

There was no statistically significant association between the ease of adjusting a hospital bed and hand length (Chi-squared = 10.95, $p < 0.05$, df = 6).

Anthropometric dimension: **Hand breadth**

Table 87

The distribution of ease of adjusting hospital beds with respect to hand breadth.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Very difficult and Difficult	6	3	13	8
Not so difficult, Easy & No response	15	13	19	11

There was no statistically significant association between the ease of adjusting a hospital bed and hand breadth (Chi-squared = 2.57 , $p > 0.05$, df = 3).

Variable: **Body Mass Index**

Body Mass Index is defined as body mass/stature^2 (kg/m^2)

Table 88

The distribution of ease of adjusting hospital beds with respect to BMI.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Very difficult & Difficult	10	12	2	6
Not so difficult, Easy & No Response	13	19	13	13

There was no statistically significant association between the ease of adjusting a hospital bed and BMI (Chi-squared = 4.13, $p > 0.05$, df = 3).

3.3.12. Heavy “portable” equipment

The dimensions tested were Stature and Body Mass Index.

In both the above cases more than 20% of the expected frequencies were below 5. In both cases the No and No response cells were combined in the following manner:

Anthropometric dimension: **Stature**

Table 89

The distribution of the perception of too heavy equipment with respect to stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	12	10	3	10
No & No response	8	17	15	13

There was no statistically significant association between the ease of picking up/moving equipment and stature (Chi-squared = 7.64, $p > 0.05$, df = 3).

Variable: **Body Mass Index**

Table 90

The distribution of the perception of too heavy equipment with respect to BMI.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	11	11	7	6
No & No response	9	27	8	9

There was no statistically significant association between the ease of picking up/moving equipment and BMI (Chi-squared = 4.09, $p > 0.05$, df = 3).

3.3.13. Controls/equipment too low for convenience

The anthropometric dimensions tested were Stature and Standing Shoulder Height.

More than 20 % of the expected frequencies were below 5, therefore the No and No response cells were combined in the following manner:

Anthropometric dimension: **Stature**

Table 91

Controls/equipment too low with respect to the distribution of stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	4	5	4	8
No & No response	12	18	18	19

There was no statistically significant association between the low position of controls / equipment and stature (Chi-squared = 0.95, $p > 0.05$, df = 3).

Anthropometric dimension: **Standing Shoulder Height**

Table 92

Controls/equipment too low with respect to the distribution of standing shoulder height.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	5	4	5	7
No & No response	13	18	22	14

There was no statistically significant association between the low position of controls / equipment and standing shoulder height (Chi-squared = 2.00, $p > 0.05$, df = 3). See figures 15-18 (pages 72-75).

3.3.14. Are there controls / equipment too high for convenience?

The anthropometric dimensions tested were Stature and Standing Shoulder Height.

More than 20 % of the expected frequencies were below 5, therefore the No and No response cells were combined in the following manner:

Anthropometric dimension: **Stature**

Table 93

Controls/equipment too high with respect to the distribution of stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	11	6	6	1
No & No response	11	15	15	23

There was a statistically significant association between Stature and equipment and/or controls that were to high for convenience (Chi-squared = 12.23, p<0.01, df=3). Twenty-four out of the 88 respondents complained that controls/equipment were to high and 64 reported no problems. Eleven of the 24 respondents in the 1st quartile for stature experienced problems. Only 1 subject with stature measurements in the 4th quartile reported inconvenience.

Anthropometric dimension: **Standing Shoulder Height**

Table 94

Controls/equipment too high with respect to the distribution of standing shoulder height.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	12	7	4	1
No & No response	8	16	17	23

There was a statistically significant association between Standing shoulder height and equipment and/or controls that were to high for convenience (Chi-squared = 18.09, p < 0.01, df = 3). Twenty-four out of the 88 respondents complained that controls/equipment were too high and 64 reported no problems. Twelve of the 24 respondents in the 1st quartile for standing shoulder height experienced problems. Only 1 subject with standing shoulder height measurement in the 4th quartile reported inconvenience.

Once again it is clear that stature and standing shoulder height are anthropometric measurements which place constraints on the design of heights of storage spaces. Ideally, the maximum acceptable heights of controls and equipment should be specified by using the 5th percentile standing shoulder height of nurses to ensure that the shorter nurses can reach these areas with ease. This would prevent potential dangerous medical situations i.e. when a nurse is too short to reach an emergency switch and it leads to detrimental complications of a patient. In the case of this study, the 5th percentile standing shoulder height of nurses is 1259 mm and stature, 1523 mm. It appears that in the facilities where the measurements were taken, anthropometric data were not used to specify the designs. See figures 19-24 (pages 77-80).

3.3.15. Handles on equipment

The anthropometric dimensions tested were Hand length, Palm length and Hand breadth.

In all three the above cases more than 20% of the expected frequencies were below 5. In all 3 cases the No and No response cells were combined and still more than 20% of the expected frequencies were below 5. In all these cases the 1st & 2nd quartiles and the 3rd and 4th quartiles were combined in the following manner:

Anthropometric dimension: **Hand length**

Table 95

Handles of equipment too small with respect to the distribution of hand length.

	1st & 2nd Quartiles	**3rd & 4th Quartiles**
Handles too small	3	11
No & No response	36	38

There was a statistically significant association between Hand length and too small handles on equipment (Chi-squared = 3.53, $p < 0.01$, df = 1). Fourteen of the 88 respondents complained about handles on equipment being too small and 74 reported no problems. Eleven out of 49 respondents in the 3^{rd} and 4^{th} quartiles for hand length reported problems with handles that are too small and 38 reported no problems. Similarly, only 3 respondents in the 1^{st} and 2^{nd} quartiles reported problems with small handles. Thirty-six respondents had no problems.

It is clear that hand length is an anthropometric variable that places constraints on the design of handles on equipment. Handles should be designed to accommodate the hand length of a 95th percentile user with ease. Ideally, the minimum acceptable size of handles on equipment should be specified by using the 95th percentile hand length. This would prevent potential dangerous medical situations i.e. when a nurse is unable to grasp emergency equipment firmly and swiftly, and it leads to detrimental complications of a patient. In the case of this study, the 95th percentile hand length of nurses is 203 mm. It appears that in the facilities where the measurements were taken, anthropometric data were not used to specify the designs of equipment.

Anthropometric dimension: **Palm length**.

Table 96

Handles of equipment too small with respect to the distribution of palm length.

	1st & 2nd Quartiles	3rd & 4th Quartiles
Handles too small	3	11
No & No response	38	36

There was a statistically significant association between Palm length and too small handles on equipment (Chi-squared = 4.24, $p < 0.01$, df = 1). Fourteen out of 88 respondents reported that handles on equipment were too small. Seventy-four reported no problems. Eleven out of 47 in the 3rd and 4th quartiles for palm length reported problems with small handles on equipment. Only 3 respondents in the 1st and 2nd quartiles reported problems with handles being too small.

Palm length is also clearly an anthropometric variable that places constraints on the design of handles on equipment. Handles should be designed to accommodate the palm length of a 95th percentile user with ease. Ideally, the minimum acceptable size of handles on equipment should be specified by using the 95th percentile palm length of the users. In the case of this study, the 95th percentile palm length of nurses is 127 mm. It appears that in the facilities where the measurements were taken, anthropometric data were not used to specify the designs of equipment.

Anthropometric dimension: **Hand breadth.**

Table 97

Handles of equipment too small with respect to the distribution of hand breadth.

	1st & 2nd Quartiles	3rd & 4th Quartiles
Handles too small	0	14
No & No response	36	38

There was a statistically significant association between Hand breadth and too small handles on equipment (Chi-squared = 11.52, $p < 0.01$, df = 1). Fourteen out of 88 respondents reported problems with the size of handles on equipment and 74 reported no problems. All 14 that complained were in the 3rd and 4th quartiles for hand breadth. No-one in the 1st or 2nd quartiles had any complaints about handle sizes on equipment.

Hand breadth is also clearly an anthropometric variable that places constraints on the design of handles on equipment. Handles should be designed to accommodate the hand breadth of a 95th percentile user with ease. Ideally, the minimum acceptable size of handles on equipment should be specified by using the 95th percentile hand breadth of the users. In the case of this study, the 95th percentile hand breadth of nurses is 93 mm. It appears that in the facilities where the measurements were taken, anthropometric data were not used to specify the designs of equipment.

Pheasant (1983) concludes that the optimal handle size of equipment for both males and females should not exceed 50 mm. Drury (1980) recommends that handles should be designed to allow the load to lifted or lowered without having the wrist in extreme positions, they should allow the weight to be distributed over the largest surface of the palm and fingers of the hand and prevent high pressure point-loadings, they should be textured to prevent the hands from slipping off the handle. As a final recommendation, the author suggests that handles should be115 mm long, have a bearing surface of 25-38 mm, and a hand clearance of 30-50 mm. See figure 25 (page 81).

3.3.16. Handles that cause pain

The anthropometric dimensions tested were Hand length, Palm length and Hand breadth.

In all three the above cases more than 20% of the expected frequencies were below 5. In all 3 cases the No and No response cells were combined in the following manner:

Anthropometric dimension: **Hand length**

Table 98

Handles on equipment that cause pain, with respect to the distribution of hand length.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	5	10	2
No & No response	15	11	17	18

There was no statistically significant association between Hand length and handles on equipment that hurt the hands (Chi-squared = 5.56, $p > 0.05$, df = 3).

Anthropometric dimension: **Palm length**

Table 99

Handles on equipment that cause pain, with respect to the distribution of palm length.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	6	7	7	7
No & No response	21	10	19	11

There was no statistically significant association between Palm length and handles on equipment that hurt the hands (Chi-squared = 2.53, $p > 0.05$, df = 3).

Anthropometric dimension: **Hand breadth**

Table 100

Handles on equipment that cause pain, with respect to the distribution of hand breadth.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	1	8	8
No & No response	11	10	22	18

There was no statistically significant association between Hand breadth and handles on equipment that hurt the hands (Chi-squared = 5.47, $p > 0.05$, df = 3).

3.3.17. Equipment with moving parts that trap the fingers

The anthropometric dimensions tested were Hand length, Palm length and Hand breadth.

In all three the above cases more than 20% of the expected frequencies were below 5. In all 3 cases the No and No response cells were combined in the following manner:

Anthropometric dimension: **Hand length**

Table 101

Equipment with moving parts that trap the fingers, with respect to the distribution of hand length.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	5	10	13	8
No & No response	17	6	16	13

There was no statistically significant association between Hand length and equipment with moving parts that hurt the hands (Chi-squared = 6.35, $p > 0.05$, df = 3).

Anthropometric dimension: **Palm length**

Table 102

Equipment with moving parts that trap the fingers, with respect to the distribution of palm length.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	8	7	12	9
No & No response	20	8	15	9

There was no statistically significant association between Palm length and equipment with moving parts that hurt the hands (Chi-squared = 2.72, $p > 0.05$, df = 3).

Anthropometric dimension: **Hand breadth**

Table 103

Equipment with moving parts that trap the fingers, with respect to the distribution of hand breadth.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	12	2	9	13
No & No response	11	6	21	14

There was no statistically significant association between Hand breadth and equipment with moving parts that hurt the hands (Chi-squared = 4.11, $p > 0.05$, df = 3). See figure 26 (page 83).

3.3.18. Work areas with inadequate space for the task to be performed

The anthropometric dimensions tested were Stature and Body Mass Index.

In both the above cases more than 20% of the expected frequencies were below 5. The No and No response cells were combined in the following manner:

Anthropometric dimension: **Stature**

Table 104

Work areas with inadequate space for the task to be performed with respect to the distribution of stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	10	12	18
No & No response	12	13	4	9

There was no statistically significant association between space in work areas and stature (Chi-squared = 6.05, $p > 0.05$, df = 3).

Variable: **Body Mass Index**

Table 105

Work areas with inadequate space for the task to be performed with respect to the distribution of BMI.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	7	15	18
No & No response	6	16	9	7

There was a statistically significant association between space in work areas and BMI (Chi-squared = 9.4, $p < 0.05$, df = 3). It seams to be the larger people who experience problems with their work space. This is clear in figures 27-33 (pages 86-91).

3.3.19. Low work surfaces

The anthropometric dimensions tested were Stature and Standing elbow height.

Anthropometric dimension: **Stature**

Table 106

The distribution of low work surfaces with respect to stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	0	8	8	10
No	16	9	7	6
No response	10	5	5	4

There was a statistically significant association between low work surfaces and stature (Chi-squared = 17.4, $p < 0.01$, df = 6). Twenty-six out of 88 respondents reported problems with work surfaces that are too low and 62 reported no problems. Ten out of 20 those in the 4th quartile for stature reported problems. None of the respondents in the 1st quartile reported any problems.

Stature is once again implicated as an anthropometric measurement which places constraints on the design of heights of work surfaces. Ideally, the minimum acceptable heights of work surfaces should be specified by using the 95th percentile stature of nurses to ensure that the taller nurses can reach these areas with ease. In the case of this study, the 95th percentile stature of nurses is 1737 mm. It appears that in the facilities where the measurements were taken, anthropometric data were not used to specify the designs.

Anthropometric dimension: **Standing elbow height**

Table 107

The distribution of low work surfaces with respect to standing elbow height.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	0	8	8	10
No	15	10	7	6
No response	10	10	3	1

There was a statistically significant association between low work surfaces and standing elbow height (Chi-squared = 21.3, $p < 0.01$, df = 6). Twenty-six out of 88 respondents reported problems with work surfaces that are too low and 62 reported no problems. Ten out of 17 in the 4th quartile for stature reported problems. None of the subjects in the 1st quartile reported any problems. This implies that tall nurses have problems reaching for low objects or bending down to write on a patients drug card, on a trolley that is too low.

Standing elbow height is clearly an anthropometric measurement which places constraints on the design of heights of work surfaces. Ideally, the minimum acceptable heights of work surfaces should be specified by using the 95th percentile standing elbow height of nurses to ensure that the taller nurses can reach these areas with ease. In the case of this study, the 95th percentile standing elbow height of nurses is 1082 mm. It appears that in the facilities where the measurements were taken, anthropometric data were not used to specify the designs. See figures 35 & 36 (pages 93-94).

3.3.20. High work surfaces

The anthropometric dimensions tested were Stature and Standing elbow height.

Anthropometric dimension: **Stature**

Table 108

The distribution of high work surfaces with respect to stature.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	6	8	2
No	0	10	9	20
No response	5	10	2	6

There was a statistically significant association between high work surfaces and stature (Chi-squared = 25.7, $p < 0.01$, df = 6). Twenty-six out of 88 respondents reported problems with work surfaces that are too high and 62 reported no problems. Ten of those who reported problems were in the 1st quartile for stature. No respondents in the 1st quartile reported that they had problems with the height of working surfaces. Similarly, only 2 of the 28 respondents in the 4th quartile for stature reported that work surfaces were too high. Twenty reported that they had no problems.

Anthropometric dimension: **Standing elbow height**

Table 109

The distribution of high work surfaces with respect to standing elbow height.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	9	4	12	1
No	0	11	8	19
No response	7	9	3	5

There was a statistically significant association between high work surfaces and standing elbow height (Chi-squared = 33.6, $p < 0.01$, df = 6). Twenty-six out of 88 respondents reported problems with work surfaces that are too high and 62 reported no problems. Nine of those who reported problems were in the 1st quartile for standing elbow height. No respondents in the 1st quartile reported that they had problems with the height of working surfaces. Similarly, only 1 out of 25 respondents in the 4th quartile for standing elbow height reported that work surfaces were too high. Nineteen reported that they had no problems.

Standing elbow height is again implicated as an anthropometric measurement which places constraints on the design of heights of work surfaces. Ideally, the maximum acceptable heights of work surfaces should be specified by using the 5th percentile standing elbow height of nurses to ensure that the shorter nurses can reach these areas with ease. In the case of this study, the 5th percentile standing elbow height of nurses is 923 mm. It appears that in the facilities where the measurements were taken, anthropometric data were not used to specify the designs.

In view of these last two statistically significant findings about work surface heights being both too high and too low, it should be recommended that these should be adjustable where possible, such as height adjustable trolleys. The height also depends on the task to be performed, e.g. in the case of a delicate task such as passing a catheter, the height should be higher than when lifting a patient up in bed. To accommodate 90% of the user population, it is recommended that standing elbow height measurements should be used to design standing work heights. In the case of this sample, the work heights should be between 923 mm and 1082 mm. See figures 37 – 44 (pages 96-99).

Design of areas such as storage shelves should also take the stature of the user population into account. In this case, to be able to accommodate 90% of the user population, the shelves should not be too high for the 5th percentile stature nurse. The 5th percentile measurement for stature in this sample is 1523 mm.

3.3.21. Seated work spaces with inadequate legroom

The anthropometric dimensions tested were Popliteal height, Buttock-popliteal length and Thigh clearance.

Anthropometric dimension: **Popliteal height**

Table 110

The distribution of work spaces with inadequate legroom with respect to popliteal height.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	0	3	5	9
No	16	13	10	1
No response	10	6	5	10

There was a statistically significant association between seated work spaces with inadequate legroom and popliteal height (Chi-squared = 23.1, $p < 0.01$, df = 6). Seventeen out of 88 respondents complained of inadequate leg room in seated work stations and 71 reported that they had no problems. Nine of those who reported problems were in the 4^{th} quartile for popliteal height. Only 1 out of 20 respondents in the 4^{th} quartile for popliteal height reported no problems. Similarly, not one out of 26 respondents in the 1^{st} quartile for popliteal height reported problems.

Popliteal height is clearly an anthropometric measurement which places constraints on the design of seated work places in respect to seat height. Ideally, the minimum acceptable heights of seats should be specified by using the 95th percentile popliteal height of nurses to ensure that the taller nurses can be seated in comfort. In the case of this study, the 95th percentile popliteal height of nurses is 464 mm. It appears that in the facilities where the measurements were taken, anthropometric data were not used to specify the designs of chairs.

In the case of Buttock-knee length and Thigh clearance more than 20% of the expected frequencies were less than 5. In both cases the No and No response cells were combined. In the case of Buttock-knee length more than 20% of the expected frequencies were still less than 5, it was therefore combined in the following manner:

Anthropometric dimension: **Buttock-popliteal length**

Table 111

The distribution of work spaces with inadequate legroom with respect to buttock-popliteal length.

	1st & 2nd Quartiles	3rd & 4th Quartiles
Yes	5	12
No & No response	38	33

There was a statistically significant association between seated work spaces with inadequate legroom and buttock-popliteal length (Chi-squared = 5.8, $p<0.05$, df = 1). Seventeen out of 88 respondents complained of inadequate leg room in seated work stations and 71 reported that they had no problems. Twelve out of 45 in the 3rd and 4th quartiles for buttock-popliteal length reported problems with legroom. Only 5 out of 43 respondents in the 1st and 2nd quartiles for buttock-popliteal height reported no problems.

Buttock-popliteal length is also clearly an anthropometric measurement which places constraints on the design of seated work places. Ideally, the minimum acceptable depth of the desk to allow sufficient legroom should be specified by using the 95th percentile buttock-popliteal length of nurses to ensure that the taller nurses can be seated in comfort. The desk should be high enough to accommodate the 95th percentile popliteal height + thigh thickness (in the case of this sample, 663 mm). In the case of this study, the 95th percentile buttock-popliteal length of nurses is 585 mm. It appears that in the facilities where the measurements were taken, anthropometric data were not used to specify the designs of seated work spaces.

Anthropometric dimension: **Thigh clearance**

Table 112

The distribution of work spaces with inadequate legroom with respect to thigh clearance.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	3	3	5	6
No & No response	26	16	22	7

There was no statistically significant association between seated work spaces with inadequate legroom and thigh clearance (Chi-squared = 7.43, $p > 0.05$, df = 3). See photographs 45 and 46 (pages 100-101).

3.3.22. Summary

When looking at the results of the associations, it is clear that it is the people at the extremes that are having the problems. The problems are therefore not randomly distributed in the population, neither are they distributed equally amongst different size people. They are the results of anthropometric factors, rather than generalised usability problems.

There are also probably different risk areas for different size people, e.g. what may be a risk for a small size person (e.g. height of controls), might not be a risk for a bigger size person.

4. Ergonomics, Nursing and Changing Populations In South Africa

4.1. General

The following are summaries of the incidence of musculoskeletal pain, the activities that cause pain, the equipment that cause problems in the ward nurses and finally, the tests of association.

Table 113.

Summary of pain prevalence by body region.

Region of Pain	Percentage of respondents suffering
1. Lumbar Backache	62.5%
2. Cervical/Shoulder Pain	40.9%
3. Foot Pain	39.8%
4. Thoracic Backache	30.7%
5. Shoulder/Arm Pain	23.9%
6. Leg Pain	22.7%
7. Hand Pain	8.0%

Table 114.

Summary of the main causes of pain.

Activities that cause pain	Percentage of respondents complaining
1. Standing	51.1%
2. Moving patients	46.6%
3. Flexion (static)	44.3%
4. Pushing beds	39.8%
5. Pulling beds	39.8%
6. Rotation of the body	39.8%
7. Lifting up heavy equipment	36.4%
8. Moving furniture	36.4%
9. Fixed postures	36.4%
10. Flexion and rotation	30.7%
11. Lifting patients and heavy equipment	30.7%
12. Leaning over patients	28.4%
13. Running and walking	23.8%
14. Stress	19.3%
15. Fatigue	12.5%
16. Stretching up onto the toes	9.1%
17. Pulling up bed cot-sides	8%
18. Holding objects for a long time	5.7%
19. Walking backwards	4.6%
20. Opening and closing cylinders	4.6%

Table 114 cont.

21. Picking up babies	3.4%
22. Rheumatoid Arthritis	2.3%
23. Varicose veins	2.3%
24. Flat feet	1.1%
25. Post-mastectomy	1.1%

Table 115.

Summary of main equipment problems.

Problem Equipment	Percentage of respondents complaining
1. Cot-sides of beds	31.8%
2. Adjusting the heads of beds	27.3%
3. Intravenous drip stands	20.5%
4. Beds, generally	19.3%
5. Television shelves	11.4%
6. Portable carts for sterile equipment	10.2%
7. Wall plugs under the beds	9.1%
8. Drug trolleys	9.1%
9. Oxygen cylinders	8%
10. CPM machine	8%
11. Air conditioner controls	8%
12. Measuring urine on the floor	6.8%
13. Image Intensifier	6.8%
14. Oxygen settings	6.8%
15. Spanners on cylinders	5.7%
16. Theatre lights	5.7%
17. Legs of theatre beds	5.7%
18. Q-cart door	5.7%
19. Defibrillator	4.6%
20. Low level storage areas	4.6%
21. Lower levels of the trolleys	4.6%
22. Arthroscopy unit	2.3%
23. Suction unit	2.3%
24. C-arm and monitors	2.3%
25. Boyles machine	2.3%
26. Oxygen bank	2.3%
27. Bedside lockers	1.1%
28. ECG machine	1.1%

Table 116. *Summary of Tests of Association*

Usability Problem/Pain	Variables Tested	Chi-squared	Degrees of Freedom	p	Statistically significant	Occurrence
1. Problems reaching for work objects	1.Stature	20.17	3	$p<0.01$	Yes	19 out of 38 in 1st quartile
	2.Grip reach	29.37	3	$p<0.01$	Yes	20 out of 38 in 1st quartile
	3. Standing Shoulder Height	33.08	3	$p<0.01$	Yes	20 out of 38 in 1st quartile
2. Problems buying clothes in a shop	1.Stature	0.77	3	$p>0.05$	No	Even distribution
	2. Hip Width	53.29	3	$p<0.01$	Yes	19 out of 30 in 4th quartile
3. Problems buying shoes in a shop	1.Foot Breadth	54.45	3	$p<0.01$	Yes	12 out of 43 in 1st quartile & 13 out of 48 in 4th quartile
	2.Foot Length	39.63	3	$p<0.01$	Yes	11 out of 34 in 1st quartile & 18 out of 34 in 4th quartile
4. Lower Backache	1.Stature	13.85	3	$p<0.01$	Yes	16 out of 55 in 4th quartile
	2.Abdominal Depth	30.35	3	$p<0.01$	Yes	15 out of 55 in 4th quartile
	3. Age	7.55	3	$p>0.05$	No	Even distribution
	4. Length of service	7.05	3	$p>0.05$	No	Even distribution
	5. Trunk Length	2.68	3	$p>0.05$	No	Even distribution
5. Thoracic Backache	1.Stature	1.96	3	$p>0.05$	No	Even distribution
	2.Length of Service	0.049	3	$p>0.05$	No	Even distribution
	3. Trunk Length	0.06	3	$p>0.05$	No	Even distribution
6. Neck / Shoulder Pain	1.Stature	12.60	3	$p<0.01$	Yes	15 out of 36 in 1st quartile
	2.Length of Service	0.74	3	$p>0.05$	No	Even distribution
	3. Standing Shoulder Height	15.07	3	$p<0.01$	Yes	16 out of 36 in 1st quartile

Table 116 cont.

7. Shoulder / Arm Pain	1.Stature 2.Grip reach 3.Length of Service 4. Standing Shoulder Height	14.37 43.07 3.54 20.89	3 3 3 3	$p<0.01$ $p<0.01$ $p>0.05$ $p<0.01$	Yes Yes No Yes	10 out of 21 in 1st quartile 17 out of 21 in 1st quartile Even distribution 11 out of 21 in 1st quartile
8. Leg Pain	1.Standing 2.Length of Service	6.75 0.67	3 3	$p>0.05$ $p>0.05$	No No	Even distribution Even distribution
9. Foot Pain	1.Length of Service	0.70	3	$p>0.05$	No	Even distribution
10. Hospital beds easy / difficult to adjust	1. Hand length 2. Hand breadth 3. BMI	10.95 2.57 4.13	6 3 3	$p>0.05$ $p>0.05$ $p>0.05$	No No No	Even distribution Even distribution Even distribution
11. "Portable" equipment too heavy	1.Stature 2.BMI	7.64 4.09	3 3	$p>0.05$ $p>0.05$	No No	Even distribution
12. Controls / equipment too low for convenience	1.Stature 2. Standing Shoulder Height	0.95 2.00	3 3	$p>0.05$ $p>0.05$	No No	Even distribution Even distribution
13. Controls / equipment too high for convenience	1.Stature 2. Standing Shoulder Height	12.23 18.09	3 3	$p<0.05$ $p<0.01$	Yes Yes	11 out of 24 in 1st quartile 12 out of 24 in 1st quartile

Table 116 cont.

14. Handles on equipment too small	1. Hand length 2. Palm length 3. Hand breadth	3.54 4.24 11.48	1 1 1	p<0.01 p<0.01 p<0.01	Yes Yes Yes	10 out of 14 in 4^{th} quartile 9 out of 14 in 4^{th} quartile 10 out of 14 in 4^{th} quartile
15. Handles that hurt your hands	1.Hand length 2. Palm length 3. Hand breadth	5.56 2.53 5.47	3 3 3	p>0.05 p>0.05 p>0.05	No No No	10 out of 14 in 4^{th} quartile Even distribution Even distribution
16. Equipment with moving parts that trap the fingers	1.Hand length 2.Palm length 3.Hand breadth	6.35 2.72 4.11	3 3 3	p>0.05 p>0.05 p>0.05	No No No	10 out of 14 in 4^{th} quartile Even distribution Even distribution
17. Work areas where space is inadequate for task to be performed	1.Stature 2.BMI	6.05 9.4	3 3	p>0.05 p<0.05	No Yes	Even distribution 18 out of 50 in 4^{th} quartile
18. Work surfaces too low	1.Stature 2.Standing elbow height	17.4 21.3	6 6	p<0.01 p<0.01	Yes Yes	10 out of 26 in 4^{th} quartile 10 out of 26 in 4^{th} quartile
19. Work surfaces too high	1.Stature 2.Standing elbow height	25.7 33.6	6 6	p<0.01 p<0.01	Yes Yes	10 out of 27 in 1^{st} quartile 9 out of 27 in 1^{st} quartile
20. Seated work spaces with inadequate leg room	1.Popliteal height 2.Buttock – knee length	23.1 4.03	6 1	p<0.01 p<0.05	Yes Yes	9 out of 18 in 4^{th} quartile 2 out of 4 in 4^{th} quartile

The present study highlights important ergonomic issues at a number of levels.

Firstly, it presents some anthropometric data on a regional population of workers in a particular industry. It confirms previous findings that nursing is a high stress profession and it provides support for the notion that part of the stress is due to variability in body size, or that high variability exacerbates musculoskeletal stress in a working population. Usability problems and pain are not randomly distributed among the nurses in this study. This suggests that part of the variance in musculo-skeletal outcomes can be accounted for by introducing an anthropometric dimension into studies. Schierhout et al. (1993) showed that ergonomic variables of force, posture and repetition were related to the probability of a person experiencing pain. The findings in this study suggest that anthropometric variables should be included in epidemiological studies of occupational musculo-skeletal pain.

Secondly, it draws attention to some general trends that are increasing the variability of working populations and therefore presenting new challenges to designers. Some skills, such as nursing, are easier to incorporate into the global economy than others, as is seen in the number of subjects in the sample that originate from foreign countries. Many private sector businesses are becoming "globalised" in a sociotechnical sense meaning that their organisational structure, technology and personnel requirements are similar irrespective of the country in which they are based. As more parts of national economies become privatised (such as education, health care, transport and telecommunications) we may expect this trend to continue (IMD/World Economic Forum, 1995). Nursing is a mobile occupation and global industries can draw on a global work force with "mobile skills". Nursing may be regarded as a mobile skill particularly in the case of private hospitals and there is therefore no reason to expect the nursing population to bear resemblance to the local population. In the case of these mobile skills, we may question the concept of "a specific user population" in a particular country or geographical area, (i.e. whether such a population actually exists). Additionally, there is no reason to expect the anthropometry of nurses in private hospitals to resemble those in State hospitals whose employment practices and remuneration packages are different.

Urbanisation of rural populations is taking place in many parts of the world. This trend is not restricted to Africa, as the same is happening in the United States of America with an influx of Hispanic people and Southeast Asians, and an influx of Southeast Asians into Australia. Urbanisation and migration often brings with it an improvement in living conditions, socio-economic status and a decrease in disease and malnutrition. All of these factors can bring about large changes in the anthropometry of a population in a generation, changes which persist across subsequent generations (See Mascie-Taylor and Bogin, 1995 for more discussion of this). These demographic changes may also be accompanied by heterosis (outbreeding) as previously isolated rural communities or populations find themselves in the same milieu as other populations. Heterosis may lead to increases in body size across generations as a result of "hybrid vigour" (Boldsen, 1995).

It is expected therefore that in the Western Cape, the combined effects of migration, heterosis and improved living conditions will lead to an increase in the size and variability of certain local groups over the next few generations. Therefore, ergonomists and designers need to be particularly sensitive the anthropometric variability, physical mismatches between workers and the work environment as well as work-related musculoskeletal injuries.

4.2. Practical Implications

The practical implications of this study centre around design. Equipment and workspaces therefore have to be designed with a changing and variable user population in mind. Equipment specifically would have to be as adjustable as possible, e.g. height adjustable trolleys, wheeled equipment should have large, low friction wheels to enable nurses of all body sizes to use with equal ease, equipment fixed onto walls should be on a height adjustable rail to enable nurses of all statures to use easily. Where workspaces are concerned, non-slip floor surfaces should be universal, properly designed platforms should be present in all areas where standing tasks are performed, patient toilets and bathrooms should be designed to accommodate at least a wheelchair and a nurse to facilitate easy transfer, storage areas should be in reach of a 5th percentile stature nurse or a stepladder should be present. In the nurses' station height adjustable chairs and footrests should be available. In manual handling tasks lifting aids should be used as much as possible. These aids should be easy to use, easy to set up, easy to access and store and be well maintained. Regular encouragement and instruction should be given about the use of manual handling aids. Manual handling in constrained and confined spaces should be avoided as much as possible.

As can be seen from the results in the questionnaire, there are numerous problems in the daily nursing routine, such as lumbar backache and other musculo-skeletal complaints, inadequate space in which to perform the nursing tasks, equipment that causes bodily discomfort, badly designed hospital beds, storage spaces that are inaccessible, poor design of toilets and bathrooms for patient use, particularly when the aid of a nurse is required. The implementation of an ergonomics programme would be a way of reducing the musculo-skeletal stress of nursing (Garg and Owen, 1992). Better and proper design of workspaces would also facilitate easier access in nursing tasks. This should ideally be done in the planning stage of a facility.

Few studies have formally tested for association between anthropometric variables and mismatches in the working environment. As can be seen from this study, very important and consistent associations were found. It is therefore important to have a valid, up to date database of anthropometric dimensions of the user population. This would be very useful information to have in the design of workstations as well as in the design and purchase of new equipment.

4.3. Conclusions

- This sample is not a fixed user population, and is expected to change and grow constantly. They are not homogenous in any of the anthropometric characteristics of a specific group, with the exception of gender i.e. only 52% of the subjects in this sample were from the Western Cape, the subjects were from a large age range, various races, ethnic groups, nationalities and different socio-economic backgrounds e.g. an immigrant from the United Kingdom and a nurse from the rural area of the Ciskei.

Designers must therefore minimise the assumptions they make about user anthropometry and attempts at "anthropometrically neutral" design of equipment and facilities.

- There are many problems related to the working environment, such as lumbar backache, workspace constraints, design of workstations and general equipment usability problems.

- Evidence was found to suggest that many of the problems are associated with body size variability.

- This population is changing and growing, therefore placing constraints on designers and management in terms of the need for adjustability.

4.4. Recommendations for future research

In the introduction of this manuscript it was stated that when designing objects and environments for human use, the dimensions and characteristics of the users should be properly considered. Future anthropometric studies might attempt to follow the example of this thesis and collect data on the consequences of mismatches as well as data on body size variability and mismatches. In view of the demographic trends mentioned earlier, this would help to heighten awareness of how important it is to include anthropometric considerations in design.

4.5. Postscript

After seeing the draft of the thesis, as well as the photographs, the management of the Leeuwendal hospital has made the following changes:

- Stepladders placed in high storage areas.
- The level of the wall plugs is higher and more accessible.
- The television stands are being lowered to an accessible level for operation.
- The nurses have all been made aware of good body mechanics at all times, and to summon help when needed.
- Recommendations regarding changes to the size of the existing patient toilets and bathrooms.
- A move is planned to a new building in the near future. The management has given the assurance that ergonomic principles will be applied in the new design of the facility.

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Appendix 1

Questionnaire

All answers will be treated in the strictest confidence.

Instructions: Cross your answer in the appropriate boxes and comment in the appropriate spaces.

Name	
Age	
Occupation	
How long in profession?	
Place of Birth	
Address	

Is your job done mostly **STANDING** or **SITTING?**	Standing	Sitting

If **SITTING**, please complete the following section:

These questions are regarding your **CHAIR**:

Height	Too High	OK	Too Low
Width	Too Wide	OK	Too Narrow
Depth (seat length)	Too Deep	OK	Too Shallow
Does it have **armrests**?	Yes	No	
Does it have a **backrest**?	Yes	No	
If **Yes** for a backrest, does it support your back?	Yes	No	

Can you keep your feet comfortably on the floor when sitting?	Yes	No	I don't know

Is your desk:	Just right	Too High	Too Low

If **Standing**, please complete this section:

How long do you perform this task whilst standing?..
....

Do you have problems reaching your work objects?	Yes	No

If **Yes**, what problems do you have? ....
....

Do you have problems buying clothes in a shop?	Yes	No

If **Yes**, what problems do you have? ....
....

Do you have problems buying shoes in a shop?	Yes	No

If **Yes**, what problems do you have? ....
....

What are your hobbies?...
....
....

Do you have pain now, or have you had pain in any of the following areas during the last year?

Lower Back	Yes	No
Mid Back	Yes	No
Neck/Shoulder	Yes	No
Shoulder/Arm	Yes	No
Hand	Yes	No
Leg	Yes	No
Foot	Yes	No

Did a **specific incident** give rise to this pain?	Yes	No

If **Yes**, describe the incident: ....
....
....

Is the **pain** associated with a **specific activity** performed at **work**?	Yes	No

If **Yes**, describe the activity: ....
....
....

How long does this pain normally last? ....

What can you do to relieve the pain? ....
....

Does any other activity cause the same **pain**?	Yes	No

If **Yes**, describe the activity: ....
....
....

Equipment:

Is "portable" equipment too heavy?	Yes	No	I don't know
Are the controls/equipment too low for convenience?	Yes	No	I don't know
Are the controls/equipment too high for convenience?	Yes	No	I don't know
Are the handles too small?	Yes	No	I don't know
Are there handles that hurt your hands?	Yes	No	I don't know
Does the equipment have moving parts that trap your fingers?	Yes	No	I don't know

If **Yes** to any of the above, please specify which items of equipment you are referring to: ....
....
....

Work Areas:

Are there work areas where the space is inadequate for the task to be performed?	Yes	No	I don't know
Are there work areas where you have to reach an arm's length or further and/or over an obstacle of some kind?	Yes	No	I don't know
Are there work areas that are too low?	Yes	No	I don't know
Are there work areas that are too high?	Yes	No	I don't know
Are there seated work spaces that have inadequate legroom?	Yes	No	I don't know

If **Yes** to any of the above, please specify the areas you are referring to:
....
....
....

Hospital beds:

What percentage are **Height** adjustable?	0%	25%	50%	75%	100%

Regarding **Adjustable** beds:

Is the **range** sufficient?	Yes	No	I don't know

How often do you adjust a Bed?	Always	Often	Sometimes	Rarely	Never

Are the beds easy/difficult to adjust?	Very difficult	Difficult	Not so difficult	Easy	Very easy

Manual Handling:

Do you ever lift or move patients?	Yes	No

If **Yes:**

Do you lift them:	Alone	With Help

Are lifting aids available?	Yes	No

If **Yes:**

Do you use lifting aids?	Yes	No

If **Yes**, what aids do you use:...
....

Are the lifting aids usable?	Yes	No

If **No,** why not? ....
....

Are they easy to operate?	Yes	No

If No, what is difficult? ....
....

Have you been trained in correct manual handling techniques?	Yes	No

Thank you for your co-operation.

Appendix 2.

Tests of association (original contingency tables)

1. Problems reaching for work objects

Anthropometric dimension: **Grip reach**

Table 117.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	20	10	3	5
No	2	10	15	20
Did not answer	1	1	0	1

Anthropometric dimension: **Stature**

Table 118

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	19	10	7	2
No	4	16	10	17
Did not answer	1	1	0	1

Anthropometric dimension: **Standing Shoulder Height**

Table 119

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	20	11	6	1
No	3	8	18	18
Did not answer	1	0	1	1

2. Problems buying clothes in a shop

Anthropometric dimension: **Stature**

Table 120

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	9	7	3	7
No	17	19	9	16
Did not answer	0	1	0	0

Anthropometric dimension: **Hip width**

Table 121

	Ist Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	4	1	2	19
No	18	28	15	0
Did not answer	0	1	0	0

3. Problems buying shoes in a shop

Anthropometric dimension: **Foot length**

Table 122

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	12	2	7	13
No	6	27	20	0
Did not answer	1	0	0	0

Anthropometric dimension: **Foot breadth**

Table 123

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	11	0	5	18
No	4	27	22	0
Did not answer	0	0	0	1

4. Lower backache

Anthropometric dimension: **Stature**

Table 124

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	5	15	19	16
No	13	10	4	4
Did not answer	0	0	1	1

Anthropometric dimension: **Abdominal depth**

Table 125

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	0	24	16	15
No	15	8	4	4
Did not answer	0	1	1	0

Variable: **Length of Service**

Table 126

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	8	11	16	20
No	13	5	7	8

Variable: **Age**

Table 127

	< 33 Years	33-39 Years	39-46 Years	>46 Years
Yes	15	13	10	17
No	9	9	11	2
No response	1	1	0	0

Anthropometric dimension: **Trunk Length**

Table 128

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	12	11	16	16
No	5	8	6	6
No Response	2	2	1	3

5. Thoracic backache

Anthropometric dimension: **Stature**

Table 129

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	5	6	9	7
No	14	14	14	15
Did not answer	1	0	1	2

Anthropometric dimension: **Trunk Length**

Table 130

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	7	8	5	9
No	16	15	12	14
Did not answer	1	1	1	1

Variable: **Length of Service**

Table 131

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	5	7	7	8
No	11	17	16	17

6. Neck / Shoulder pain

Anthropometric dimension: **Stature**

Table 132

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	15	12	5	4
No	8	10	16	13
Did not answer	0	2	0	3

Anthropometric dimension: **Standing Shoulder Height**

Table 133

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	16	13	4	3
No	8	10	13	16
Did not answer	1	2	0	2

Variable: **Length of service**

Table 134

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	7	8	9	12
No	15	11	12	14

7. Shoulder / Arm Pain

Anthropometric dimension: **Stature**

Table 135

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	5	4	2
No	7	16	18	23
Did not answer	1	0	0	2

Anthropometric dimension: **Standing Shoulder Height**

Table 136

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	11	6	3	1
No	6	15	19	24
Did not answer	1	1	0	1

Anthropometric dimension: **Grip reach**

Table 137

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	17	1	2	1
No	5	14	22	23
Did not answer	1	0	0	2

Variable: **Length of Service**

Table 138

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	6	3	3	9
No	16	18	16	17

Painful hands

Variable: **Length of Service**

Table 139

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	3	2	0	2
No	21	19	19	22

8. Leg pain

Variable: **Hours standing per day**

Table 140

	4-6 Hours	6-8 Hours	8-10 Hours	10-12 Hours
Yes	6	2	5	7
No	17	16	14	16
Did not answer	1	2	1	1

Variable: **Length of Service**

Table 141

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	3	6	5	6
No	15	16	18	19

Painful feet

Variable: **Length of Service**

Table 142

	< 9 Years	9-17 Years	17-22 Years	> 22 Years
Yes	7	9	9	10
No	11	13	11	18

9. Hospital bed adjustment (easy / difficult)

Anthropometric dimension: **Hand length**

Table 143

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Very difficult	0	1	2	3
Difficult	7	2	6	7
Not so difficult	4	6	8	4
Easy	4	10	2	4
Did not answer	5	3	5	5

Anthropometric dimension: **Hand Breadth**

Table 144

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Very difficult	3	0	1	2
Difficult	3	3	12	6
Not so difficult	7	4	5	4
Easy	3	5	9	3
Did not answer	5	4	5	4

Anthropometric dimension: **Body Mass Index**

Table 145

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Very difficult	3	4	0	1
Difficult	7	8	2	5
Not so difficult	6	7	4	4
Easy	2	5	4	8
Did not answer	5	7	5	1

10. Perceived heaviness of "portable" equipment

Anthropometric dimension: **Stature**

Table 146

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	12	10	3	10
No	7	13	11	9
Did not answer	1	4	4	4

Variable: **Body Mass Index**

Table 147

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	11	11	7	6
No	7	17	7	9
Did not answer	2	10	1	0

11. Controls / equipment too low for convenience

Anthropometric dimension: **Stature**

Table 148

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	4	5	4	8
No	10	14	17	13
Did not answer	2	4	1	6

Anthropometric dimension: **Standing Shoulder Height**

Table 149

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	5	4	5	7
No	10	15	16	13
Did not answer	3	3	6	1

12. Controls / equipment too high for convenience

Anthropometric dimension: **Stature**

Table 150

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	11	6	6	1
No	6	12	14	18
Did not answer	5	3	1	5

Anthropometric dimension: **Standing Shoulder Height**

Table 151

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	12	7	4	1
No	4	12	15	19
Did not answer	4	4	2	4

13. Handles on equipment too small

Anthropometric dimension: **Hand length**

Table 152

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	2	1	1	10
No	16	15	18	12
Did not answer	2	3	6	2

Anthropometric dimension: **Palm length**

Table 153

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	0	3	2	9
No	25	10	16	10
Did not answer	2	1	9	1

Anthropometric dimension: **Hand breadth**

Table 154

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	0	0	4	10
No	17	15	22	8
Did not answer	4	0	5	3

14. Handles that cause pain

Anthropometric dimension: **Hand length**

Table 155

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	5	10	2
No	15	8	10	17
Did not answer	0	3	7	1

Anthropometric dimension: **Palm length**

Table 156

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	6	7	7	7
No	20	7	13	10
Did not answer	1	3	6	1

Anthropometric dimension: **Hand breadth**

Table 157

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	1	8	8
No	10	9	17	14
Did not answer	1	1	5	4

15. Equipment with moving parts that trap the fingers

Anthropometric dimension: **Hand length**

Table 158

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	5	10	13	8
No	16	4	9	11
Did not answer	1	2	7	2

Anthropometric dimension: **Palm length**

Table 159

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	8	7	12	9
No	19	8	13	9
Did not answer	1	0	2	0

Anthropometric dimension: **Hand breadth**

Table 160

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	12	2	9	13
No	10	6	14	14
Did not answer	1	0	7	0

16. Work areas where the space is inadequate for the task to be performed

Anthropometric dimension: **Stature**

Table 161

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	10	12	18
No	3	4	2	5
Did not answer	9	9	2	4

Anthropometric variable: **Body Mass Index**

Table 162

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	7	15	18
No	2	6	2	4
Did not answer	4	10	7	3

17. Low work surfaces

Anthropometric dimension: **Stature**

Table 163

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	0	8	8	10
No	16	9	7	5
Did not answer	10	5	5	4

Anthropometric dimension: **Standing elbow height**

Table 164

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	0	8	8	10
No	15	10	7	6
Did not answer	10	10	3	1

18. High work surfaces

Anthropometric dimension: **Stature**

Table 165

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	10	6	8	2
No	0	10	9	20
Did not answer	5	10	2	6

Anthropometric dimension: **Standing elbow height**

Table 166

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	9	4	12	1
No	0	11	8	19
Did not answer	7	9	3	5

19. Seated work spaces with inadequate legroom

Anthropometric dimension: **Popliteal height**

Table 167

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	0	3	5	9
No	16	13	10	1
Did not answer	10	6	5	10

Anthropometric dimension: **Buttock-popliteal length**

Table 168

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	2	3	10	2
No	15	13	11	1
Did not answer	5	5	10	11

Anthropometric dimension: **Thigh clearance**

Table 169

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Yes	3	3	6	6
No	16	11	12	1
Did not answer	10	5	10	6

Appendix 3

In this appendix the responses of the ward nurses and nursing managers are compared by using the chi-squared test.

The questionnaire was given to ward nurses as well as a group of nursing managers (sedentary nurses) to find out about the impact of stressful working environments on the incidence of musculoskeletal pain.

The aim was also to ascertain whether the questionnaire is capable of differentiating between different working circumstances and work stresses. For example, one would not expect a difference in the ability to buy clothes (chi-squared = 2.94, $p > 0.05$ and df=1) and shoes (chi-squared = 1.94, $p > 0.05$ and df=1) in a shop (which was indeed the case). In contrast, one would expect a difference in work-related lower backache between the 2 groups. Eight out of 22 nursing managers and 55 out of 88 ward nurses reported lower backache. There was a statistically significant difference in the incidence of low back pain between the 2 groups (chi-squared = 4.91, $p < 0.05$ and df =1).

Table 170

Is the job mostly Standing or Sitting?	**Ward Nurses (N=88)**	**Nursing Managers (N=22)**
Mostly Standing	77	0
Mostly Sitting	2	22
Standing and Sitting	9	0

Chi-squared = 98.54, $p< 0.01$, df = 3.

The is an obvious difference and the significance is not surprising, as all the nursing managers reported that they sit most of their working day, whereas the ward nurses are on their feet most of the time.

Table 171

Problems reaching for objects at work?	Ward Nurses (N=88)	Nursing Managers(N=22)
Yes	38	2
No & no response	50	20

Chi-squared = 8.84, $p < 0.01$, df = 1.

As can be seen from the figures in the main text, there were many areas where the work place design is poor and the ward nurses need to reach for work objects a lot more than the nursing managers who are mostly desk bound.

Table 172

Problems buying clothes in a shop?	Ward Nurses (N=88)	Nursing Managers(N=22)
Yes	26	3
No & no response	62	19

Chi-squared = 2.94, $p > 0.05$, df = 1.

Table 173

Problems buying shoes in a shop?	Ward Nurses (N=88)	Nursing Managers (N=22)
Yes	34	5
No & no response	54	17

Chi-squared = 1.94, $p > 0.05$, df = 1.

One would not have expected a statistically significant difference in the responses of the 2 groups on this problem of buying clothes or shoes in a shop.

Pain in any of the following areas:

Table 174

Lumbar region	Ward Nurses (N=88)	Nursing Managers (N=22)
Yes	55	8
No & no response	33	14

Chi-squared = 4.91, $p < 0.05$, df = 1.

As discussed in the introduction of this section above, it was expected to find a difference in the occurrence due to the different nature and stresses in the 2 jobs.

Table 175

Thoracic region	Ward Nurses (N=88)	Nurse Managers (N=22)
Yes	27	6
No & no response	61	16

Chi-squared = 0.097, $p > 0.05$, df = 1.

There was no statistically significant difference in the occurrence of thoracic backache in the 2 groups of respondents.

Table 176

Cervical / Shoulder region	Ward Nurses (N=88)	Nurse Managers (N=88)
Yes	36	11
No & no response	52	11

Chi-squared = 0.59, $p > 0.05$, df = 1.

There was no statistically significant difference in the occurrence of cervical/shoulder pain in the 2 groups of respondents.

Table 177

Shoulder / Arm region	Ward Nurses (N=88)	Nurse Managers (N=22)
Yes	21	7
No & no response	67	15

Chi-squared = 0.59, $p > 0.59$, df = 1.

There was no statistically significant difference in the occurrence of shoulder/arm pain in the 2 groups of respondents.

Table 178

Hands	Ward Nurses (N=88)	Nurse Managers (N=22)
Yes	7	5
No & no response	81	17

Chi-squared = 3.95, $p < 0.05$, df = 1.

There was a statistically significant difference in the occurrence of hand pain in the 2 groups of respondents. Five out of 22 nursing managers, and 7 out of 88 ward nurses reported hand pain. The hand pain experienced by the nurse managers is probably due to the amount of typing and writing that they are exposed to.

Table 179

Legs	Ward Nurses (N=88)	Nurse Managers (N=22)
Yes	20	0
No & no response	68	22

Chi-squared = 6.11, $p < 0.05$, df = 1.

There was a statistically significant difference in the occurrence of leg pain in the 2 groups. No nursing managers reported any leg pain, whereas 20 out of 88 ward nurses reported leg pain. The leg pain experienced by the ward nurses is probably due to the amount of time spent standing and walking around during their long shifts.

Table 180

Feet	Ward Nurses (N=88)	Nurse Managers (N=22)
Yes	35	1
No & no response	53	21

Chi-squared = 10.44, $p < 0.01$, df = 1.

There was a statistically significant difference in the occurrence of painful feet in the 2 groups. Only 1out of 22 nursing managers reported any leg pain, whereas 35 out of 88 ward nurses reported leg pain. The foot pain experienced by the ward nurses is probably due to the amount of time spent standing and walking around during their long shifts.

Table 181

Did a specific incident give rise to the pain?	Ward Nurses (N=88)	Nurse Managers (N=22)
Yes	37	10
No & no response	51	12

Chi-squared = 0.08, $p > 0.05$, df = 1.

It was not expected to find a statistically significant difference between the 2 groups of respondents.

Table 182

Is the pain related to specific activity at work?	Ward Nurses (N=88)	Nurse Managers (N=22)
Yes	68	10
No & no response	20	12

Chi-squared = 8.64, $p < 0.01$, df = 1

There was a statistically significant difference between the work-relatedness of musculoskeletal pain. Ten out of 22 nursing managers (less than half of the respondents) reported their pain as being work-related, while 68 out of 88 ward nurses (77%) reported work-related musculoskeletal pain. This is probably due to the more physically stressful nature of ward nursing.

Table 183

Do other activities cause the same pain?	Ward Nurses (N=88)	Nurse Managers (N=22)
Yes	21	6
No & no response	67	16

Chi-squared = 0.11, $p > 0.05$, df = 1.

There was no statistically significant difference between the 2 groups. This was also not expected to be different, as different people partake in completely different activities away from the work place.

Equipment:

Table 184

Is "portable" equipment too heavy?	Ward Nurses (N=88)	Nursing Managers (N=22)
Yes	35	4
No & no response	53	18

Chi-squared = 3.59, $p > 0.05$, df = 1.

There was no statistically significant difference in the responses of the 2 groups. Both groups reported on equipment that was deemed to heavy, such as ECG machines in the case of the ward nurses, and overhead projectors in the case of the nursing managers.

Table 185

Controls/Equipment too low for convenience?	Ward Nurses (N=88)	Nursing Managers (N=22)
Yes	21	2
No & no response	67	18

Chi-squared = 1.86, $p > 0.05$, df = 1.

There was no statistically significant difference in the responses of the 2 groups.

Table 186

Controls/Equipment too high for convenience?	Ward Nurses (N=88)	Nursing Managers (N=22)
Yes	24	2
No & no response	64	18

Chi-squared = 2.66, $p > 0.05$, df = 1.

There was no statistically significant difference in the responses of the 2 groups.

Table 187

Are the handles too small?	Ward Nurses (N=88)	Nursing Managers (N=22)
Yes	14	0
No & no response	74	22

Chi-squared = 4.01, $p < 0.05$, df = 1.

There was a statistically significant difference in the responses of the 2 groups. No nursing manager reported a problem with handles that were to small, whereas 14 out of 88 ward nurses reported problems. The handles mentioned were the ECG machine, bedside lockers and storage drawers. This reflects on the poor design of the working environment and equipment.

Table 188

Are there handles that hurt your hands?	Ward Nurses (N=88)	Nursing Managers (N=22)
Yes	27	3
No & no response	61	19

Chi-squared = 2.58, $p > 0.05$, df= 1.

There was statistically significant difference between the responses of the 2 groups.

Table 189

Equipment with moving parts that trap the fingers?	Ward Nurses (N=88)	Nurse Managers (N=22)
Yes	36	3
No & no response	52	19

Chi-squared = 5.72, $p < 0.05$, df = 1.

There was a statistically significant difference in the responses of the 2 groups. Only 3 out of 22 nursing managers reported problems with equipment that traps the fingers, while 36 out of 88 ward nurses reported the same problem. The cot-sides of the beds were reported by the ward nurses to be the biggest problem.

Table 190

Work areas inadequate for task to be performed?	Ward Nurses (N=88)	Nursing Managers (N=22)
Yes	50	6
No & no response	38	16

Chi-squared = 6.14, $p < 0.05$, df = 1.

There was a statistically significant difference in the responses of the 2 groups. Fifty out of 88 ward nurses reported inadequate work space, while only 6 out of 22 nursing managers found the same problem. As seen in the photographs in the main text, there are many areas in the wards where the space is inadequate for the task performance. In many cases, for example, the bed has to be moved towards the middle of the ward to enable the ward nurses to perform certain procedures on the wall side of the beds.

Table 191

Are there work areas where you have to reach further than an arm's length?	Ward Nurses (N=88)	Nursing Managers (N=22)
Yes	42	5
No & no response	46	17

Chi-squared = 4.49, $p < 0.05$, df = 1.

There was a statistically significant difference between the responses of the 2 groups. Forty-two out of 88 ward nurses reported problems, while only 5 out of 22 nursing managers reported problems. Once again the poor design of the hospital environment is highlighted. In the main text many photographs illustrate this problem.

Table 192

Are there work surfaces that are too low?	Ward Nurses (N=88)	Nursing Managers (N=22)
Yes	26	3
No & no response	62	19

Chi-squared = 2.29, $p > 0.05$, df = 1.

There was no statistically significant difference in the responses of the 2 groups.

Table 193

Are there work surfaces that are too high?	Ward Nurses (N=88)	Nursing Managers (N=88)
Yes	26	5
No & no response	62	17

Chi-squared = 0.4, $p > 0.05$, df = 1.

There was no statistically significant difference in the responses of the 2 groups.

Table 194

Seated workspaces that have inadequate legroom?	Ward Nurses (N=88)	Nursing Managers (N=22)
Yes	17	5
No & no response	71	17

Chi-squared = 0.13, $p > 0.05$, df = 1

There was no statistically significant difference in the responses of the 2 groups.

Summary

As can be seen, the problems experienced are not randomly assorted in the working environment. They are due to the difference in job and musculoskeletal stresses imposed on the different groups of nurses.