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ISOKINETIC DYNAMOMETER NORMS OF TRUNK MUSCLE EXTENSION FOR REGISTERED FEMALE NURSES

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled PRELIMINARY ISOKINETIC DYNAMOMETER NORMS OF TRUNK MUSCLE EXTENSION FOR FEMALE REGISTERED NURSES submitted by ERIN K. PAYETTE in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE.

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DATE__________________, 1992

DEDICATION

I would like to dedicate this thesis to three extremely important individuals;

my mother, Audrey, whose independence encouraged me,

my grandmother, Eva, whose perseverance inspired me, and

my husband, Michael, for all of his guidance, help, and understanding.

ABSTRACT

Occupational low back pain is a major source of suffering, incapacitation and cost to the world today. Occupational low back pain is prevalent in nursing due to lifting, bending and pulling, usually of a patient. Trunk extensor muscular strength and endurance are essential requirements for almost all nursing duties. Contemporary trunk muscle performance tests analyze concentric and isometric muscle contractions of trunk extension, flexion and rotation but trunk muscle performance testing of specific occupations and eccentric muscle contractions are minimal.

Seventy-nine female registered nurses (19-58 years of age) from hospitals in the Edmonton area (approx. 87% of the sample being from the University of Alberta Hospitals) performed trunk muscle strength and endurance testing, through a 60° range of motion, at 30°/second, using the Kin-Com isokinetic dynamometer. Peak torque, angle of peak torque, average torque and the relationship between peak concentric and peak eccentric torque were identified for trunk extensor concentric and eccentric muscular strength. Total work completed and a muscular endurance fatigue index were calculated for trunk extensor concentric and eccentric muscular endurance. Normative data, for the preceding variables, were compiled into tables of percentile rankings and histograms.

Trunk extensor eccentric peak torque (198.1 ±54.4 Nm)

was higher than the trunk extensor concentric peak torque (149.5 ±47.2 Nm). The trunk extensor concentric peak torque was 76.2 % of the trunk extensor eccentric peak torque. Over three maximal, voluntary contractions, the computer average eccentric torque (134.8 ±36.1 Nm) was higher than the computer average concentric torque (97.0 ±30.1 Nm). The total eccentric work completed during a 90 second trunk extensor muscular endurance test (2000.8 ±603.7 J) was higher than the total concentric work completed (1865.8 ±518.8 J) ($p<.01$).

A compilation of trunk muscle performance data could benefit and enhances the development of possible pre-employment screening, aids practitioners in the rehabilitative process following injury, and aid in establishing safe work loads for nurses.

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

Occupational low back pain is a major source of suffering, incapacitation and cost to the world today. Low back pain is frequent enough to affect up to 80% of the working population at some point in their working careers (Tak-sun, 1984; Waddell, 1987; Triolo, 1989), with most of the initial episodes occurring between the ages of 20-40 years (Chaffin, 1974). Machine operators, truck drivers, and the nursing profession (including registered nurses and nursing aides and orderlies) are occupations where the largest incidence of compensable back injuries occur (Klein, 1984). A number of investigators have revealed the unusually high incidence of occupational low back pain in nursing (Cust, 1972; Hoover, 1973; Dehlin, 1976; Reed, 1980; Stubbs, 1983a; Harber, 1985). Overexertion associated with actions such as lifting, bending and pulling (usually of a patient) are responsible for the occupational low back pain. (Levitt, 1971; Snook, 1978; Johnston, 1982; Alberta W.C.B., 1990).

The task of lifting is a complex process that includes both a biomechanical and physiological component. Trunk muscular performance, especially trunk extensor endurance, is an important occupational demand in occupations where repetitive motion tasks are performed in a fixed and constraint posture (Jorgensen, 1987). Some physical duties of nursing (ie. lifting/transferring patients) fall into this category. Currently, trunk muscle performance research studies analyze eccentric and concentric muscle contractions of trunk extension, flexion, and rotation. The muscle contractions are measured in a static position (isometrically) or through a dynamic range of motion (isokinetically). Instruments used to assess trunk muscle performance include the Cybex dynamometer (Beimborn, 1988), the Kin-Com Isokinetic dynamometer and the B-200 Isostation (Parnianpour, 1987). Unfortunately, analysis of trunk muscle performance, of different occupations, is minimal.

Occupational low back pain, resulting from overexertion of lifting, bending and pulling, is prevalent in nursing. Analysis of trunk muscle performance (of nurses), needs to be assessed, since research of this nature does not exist in the literature. A compilation of trunk muscle performance data (ie. normative isokinetic dynamometry data) could benefit and enhance the development of pre-employment screening, aid practitioners with rehabilitative progress following injury and aid in establishing safe work loads for nurses.

The Purpose of the Study

The purpose of this study was to investigate the isokinetic trunk muscle performance of female registered nurses. The variables to be assessed were:

1. concentric/eccentric isokinetic muscular strength of the trunk extensors.
2. concentric/eccentric isokinetic muscular endurance of the trunk extensors.
3. the relationship between the concentric and eccentric isokinetic muscle contractions of the trunk extensor muscular strength.

Operational Definitions of Terms

Low Back Pain - refers to pain experienced in the lumbar spine region from the inferior costal border to the gluteal fold, excluding menstrual cramps and/or leg fatigue not associated with low back pain (Cato, 1989).

Occupational Low Back Pain - refers to low back pain as a result of job related duties. In nursing, occupational low back pain refers to low back pain related to working on the nurse's present unit (Cato, 1989).

Low Back Injury - refers to any injury pertaining to the low back area, regardless if a diagnosis has been identified or not.

Compensable Back Injury - refers to a painful back injury that occurred while 'on the job'. A compensable back injury can be associated with days off work and financial compensation to the injured employee, and a financial obligation for the employer.

Female Registered Nurse (R.N.) - refers to a female having completed a college, hospital or university nursing program and has successfully completed the registered nurses' qualification exams (administrative or supervising nurses included).

Part Time Employment - refers to working, on a nursing unit, for 20 - 32 hours per work. The shifts may be 8 to 12 hours in duration.

Full Time Employment - refers to working, on a nursing unit, 37.5 hours per week or more. The shifts may be 8 to 12 hours in duration.

Maximum Strength - refers to the peak torque developed during a maximal voluntary contraction (MVC) at a given angle or through a range of motion. For example, isokinetic trunk extensor concentric maximum strength refers to the peak torque produced by one of the six isokinetic trunk extensor concentric repetitions.

Trunk Isokinetic Concentric Muscle Contraction - refers to the contraction of the trunk muscles, when forced to shorten at a constant velocity, resulting in the development of tension within the muscle(s). The net muscle movement is in the same direction as the change in the joint angle (Williams, 1992).

Trunk Isokinetic Eccentric Muscle Contraction - refers to the contraction of the trunk muscles, when forced to lengthen by an external load at a constant velocity, resulting in the development of tension within the muscle(s). The net muscle movement is in the opposite direction as the change in the joint angle (Williams, 1992).

Torque - refers to the force generated about an axis of rotation during a MVC. Torque is the product of force multiplied by the perpendicular distance from the axis of rotation and is expressed as Newton meters (Nm). (1Nm = .738 ft.lb.).

Work - refers to the total force generated about an axis of rotation during a series of contractions. Work is the product of force (of the series of contractions) multiplied by the perpendicular distance from the axis of rotation and is expressed in Joules (J). (1J = 1Nm).

Muscular Endurance - refers to the total amount of work produced during a 90 second trunk extensor endurance test.

Trunk Extensor Muscular Fatigue Index - refers to a calculated expression of the fatigability of the trunk extensor muscles (during concentric or eccentric muscular contractions) during the 90 second endurance test. To calculate the muscular fatigue index, as pertaining to this study, the following steps must be followed:

1. Calculate the work (in joules) per repetition during the three maximum repetition strength test, that produced peak torque

$$\frac{\text{Total work of 3 repetitions (J)}}{3} = x1$$

2. Calculate the work (in joules) per repetition during the 90 second (20 repetition) endurance test.

$$\frac{\text{Total work of 20 repetitions (J)}}{20} \quad x2$$

3. Divide x2 by x1

A value over one (1) indicates minimal (or decreased) fatigability of the trunk extensor muscles, therefore an increase in productivity (actual work per repetition) is apparent. A value under one (1) indicates maximal (or increased) fatigability of the trunk extensor muscles, therefore a decrease in productivity (actual work per repetition) is apparent.

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<------|------|------|------┐------|------|------|------>
     etc.    .8     .9      1     1.1    1.2    etc.
<---------------------------||--------------------------->
  -increased (or maximal)        -decreased (or minimal)
       fatigability                   fatigability
  -decreased productivity        -increased productivity
```

Diagram 1.1 A Diagrammatical Representation for Interpreting the Trunk Extensor Muscular Fatigue Indices

Abbreviations

1.	HT	Height (cm)
2.	WT	Weight (kg)
3.	Nm	Newton meters
4.	J	Joules
5.	CPT	Concentric peak torque (Nm)
6.	CAPT	Concentric angle at peak torque (degrees)
7.	EPT	Eccentric peak torque (Nm)
8.	EAPT	Eccentric angle at peak torque (degrees)
9.	%CPT/EPT	Percentage of concentric peak torque to eccentric peak torque
10.	-CT	Computer calculated average torque of 3 maximum concentric repetitions (Nm)
11.	-ET	Computer calculated average torque of 3 maximum eccentric repetitions (Nm)
12.	W20C	Total work of twenty concentric contractions (J)
13.	W20E	Total work of twenty eccentric contractions (J)
14.	FIC	Fatigue Index Concentric
15.	FIE	Fatigue Index Eccentric

Limitations of the Study

The major limitations of this study were:

1. The subjects who participated in this study were volunteers, and hence, the subject group may not be

representative of the target population.

2. Extraneous variables such as body height and weight were not controlled and may have had some effect on the results.
3. The inability to ensure that the subjects are making maximal efforts while performing the trunk extensions. However, verbal encouragement for maximal performance was given to each subject by the tester during the testing session.
4. The subject group was restricted to females.

Delimitations of the Study

The major delimitations of this study were:

1. The subject sample was restricted to active female registered nurses from the Edmonton area, in the Province of Alberta, Canada. Administrative and supervising nurses were included in the study providing that they still participated in nursing tasks on the wards, on a daily basis.
2. The testing sessions were conducted prior to, during or after a working shift or on a day off.
3. Female registered nurses who a) have experienced low back pain within the last twelve months, b) have ever experienced a disc or neural problem of the lower back, c) have ever required surgery to repair a vertebrae or

d) were pregnant were excluded from participation in the study.

4. The Kinetic Communicator or Kin-Com isokinetic dynamometer (Chattex Corporation, Chattanooga, Tennessee) was used to analyze the trunk extensor muscular strength and endurance of female registered nurses.

5. The trunk extensor muscular strength and endurance was assessed from a seated position.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The purpose of this review is to; 1) identify the occurrence of low back pain in industry, 2) identify the occurrence of low back pain in the nursing profession, 3) identify the physical demands of nursing, 4) present current literature available on the measurement of trunk muscle performance, 5) present current literature available on women and the measurement of trunk muscle performance and 6) identify the pertinent characteristics of the trunk muscles.

Occurrence of Low Back Pain in Industry

Low back pain is a prevalent occupational health problem. Working individuals have an 80% chance of experiencing some form of low back pain throughout their working career (Tak-sun, 1984; Waddell, 1987; Triolo, 1989). Freymoyer (1987) identified that each year 5% of American adults will experience an episode of low back pain. Currently, 75 million Americans suffer from some form of back problem (Kelsey, 1980) and each year seven million new cases develop. Of the new cases developing, two million workers will be unable to return to work. Norby (1981) identified that 93 million work days are lost yearly, in the United States, due to low back pain, second only to the common cold. Even though most of the individuals with low back pain will recover within the first six months, studies indicate that up to 90% of the costs (of treating injured workers) are related to the treatment of only 10% of the injured people who are disabled for more than six months (Benn, 1975; Pheasant, 1977; Cats Baril, 1985).

Nearly 2% of the total United States industrial work force will suffer a compensable back injury annually (Klein, 1984). When comparing the total number of occupational low back injuries with those of all reportable occupational injuries, there is a similarity in the figures from Great Britain (27%), Ontario, Canada (25%), and the United States (19-29%) (Tak-sun, 1984 ; Klein, 1984). If an injured worker does not return to work within a year as a result of a compensable back injury, chances of ever returning to work are minimal (Frymoyer, 1987). Billions of dollars in Workers' Compensation back claims are spent annually by the United States and Canadian employers (National Safety Council, 1973-1981), not to mention the thousands of lost work days attributed to occupational back injuries.

Occupations with the largest incidence of compensable back injuries are machine operators, truck drivers and the nursing professions (Klein, 1984). Jensen (1987) recognized that members of the nursing profession are as likely to sustain a compensable low back injury as are workers in heavy load handling occupations (such as construction labourers, rubbish collectors and warehouse workers). The most frequent type of event producing compensation claims for compensable low back injuries has been over exertion associated with actions such as lifting, bending and pulling (Levitt, 1971; Snook, 1978; Johnston, 1982; Tak-sun, 1984). Troup (1981) identified the combination of lifting, with lateral bending or twisting as a frequent cause of low back injuries in the workplace. Manning (1981) has also suggested slipping as a plausible cause for compensable low back injuries.

Local muscular fatigue potentially predisposes an individual to injury (Bates, 1977). Several studies cited in the industrial engineering literature indicate that the skill of the worker is affected by fatigue (Bates, 1977; Asmussen, 1979; Granjean, 1981; Holding, 1983). Despite the relationship of muscular endurance and fatigue in industry, few studies analyzing the dynamic endurance of the trunk muscles have been reported (Troup, 1981; Langrana, 1984)

Low back pain in industry is on the rise. Researching the causes and consequences of occupational low back pain is essential, in order to diminish this expensive health care trend which is filled with pain and suffering.

Occurrence of Low Back Pain in Nursing

A review of the literature identified the scope of the problem of low back pain in nursing. Data from six pertinent studies revealed unusually high incidences of occupational low back pain in the nursing profession:

1. During 1970, Hoover reported the nursing staff (1,520 nurses) of a large Massachusetts hospital (Wilmington Medical Centre) accounted for 67 percent of the hospitals total lifting injuries. The housekeeping staff, the only other department that contributed a significant number of lifting injuries, accounted for nearly 13 percent of the hospital's lifting injuries. Of the total 481 lost work days accumulated through all injuries in the hospital, 192 (or 40 percent) of the lost work days were due to job-related back injuries. In 1972, the personnel department at the Wilmington Medical Centre estimated the average cost to the employer for each job related accident; lifting injuries were by far the most expensive. The inability of the person to return to his/her job after a back injury is often the most serious and expensive problem (Hoover, 1973).
2. Cust (1972) identified the prevalence of low back pain in Scottish nurses to be 34.6% in a Scottish case/control study. Low back pain was attributed to occupational factors of nursing.

3. Dehlin (1976) identified (via interviews) a 46.8% occurrence of back incidence among 269 female nursing aides in a Swedish geriatric hospital (Vasa Hospital, Gothenburg, Sweden). Eighty three of the 126 nursing aides interviewed, developed their low back symptoms after starting to work as a nursing aide. Eighty-two percent of the nursing aides considered the work of a nursing aide to exert a heavy or moderately heavy strain on the back. Lifting a patient was considered the heaviest task by 72.2% of the study sample, while 21% considered bed-making, in a stooped position, to be the heaviest task with regards to the load on the back. Reoccurrence of low back pain symptoms were common, appearing in 82% of the study sample. Dehlin pointed out that the degree of absenteeism is higher among those doing heavy labour, since they were unable to work with their symptoms. North American nursing aides and registered nurses participate in many similar tasks (for example, lifting and transferring of patients of various body weights), thus both types of health care professionals are susceptible to occupational low back pain.
4. The British Royal College of Nursing Working Party reported the prevalence of back pain among nurses was as great, if not more, than that among industrial manual workers (Reed, 1980). It was estimated that over

20,000 nurses sustain back injuries each year as a result of lifting and moving patients. An average of two weeks absenteeism from work was observed for each reported incidence. A total annual cost to the National Health Service was approximately $500,000.00 (in health care costs).

5. In 1983, Stubbs surveyed 3,912 nurses in the South East region of England, via a confidential, retrospective questionnaire, on back pain incidents. Four Hundred and thirty-one per 1,000 nurses, or 43.1% of the nurses, suffered from back pain during the previous year. One hundred and fifty-nine per 1,000 nurses, or 15.9% (1 in 6) of the nurses who suffered from back pain attributed the onset of pain to a specific patient-handling incident. Approximately 54% of the nurses identified the low back as the area(s) affected by their most recent episode of back pain, whereas 27.5% of the nurses identified multiple sites as the area affected by their most recent episode of back pain. The remaining 18.8% of the nursing sample identified either the upper back and neck, mid-back, or buttocks and legs as the area affected by their most recent episode of back pain. If the results from the survey are extrapolated to the 430,000 nurses in the National Health Service (in England), it can be estimated that 40,000 nurses have sick leave for back pain each year,

with an annual total of 764,000 work days lost from this cause. In a previous study, Stubbs (1981b) also indicated significantly more back pain, attributed to client handling, in geriatric, general medical, orthopaedic and district nursing.

6. Harber (1985), conducted a retrospective recall analysis survey of 550 nurses to systematically assess the frequency of occupational low back pain among the nursing staff of a large urban general hospital (in California). Fifty-two percent of the subjects had developed occupational low back pain within 6 months prior to the study, and 44% (37% of which indicated their back pain was due to work) had experienced low back pain within two weeks of the study. Twenty-nine percent of the nurses took medication for their low back pain and 9% missed work due to the low-back pain. Even though the data indicated a high overall frequency of occupational low back pain, it may not be reflecting an accurate portrayal of injury statistics (Harber, 1985). Traditionally, counting physician visits by individuals and tabulating lost work time, are methods that have been used to tabulate the frequency of back injuries. Since nurses are health care professionals, they might have a tendency to 'treat themselves' or seek informal physician consultation. Thus, the frequency of back injuries, in a hospital setting, may

be underestimated, which downplays the significance of the problem of occupational low back pain in nursing. Lifting a patient in bed, moving beds and helping patients out of bed were the activities most commonly reported to be associated with back pain, regardless of the unit the nurse was working on at the time of injury.

In 1990, the Alberta Workers' Compensation Board, in Alberta (Canada), revealed that 305 back injury claims were filed by registered nurses, which represented 50.2% of all registered nurses' claims. The total compensation days (or lost work days) was approximately 12,948 days, with a cost of approximately $1,259,712.00. The major types of recorded accidents were overexertion due to lifting of an object or overexertion not otherwise classified. By comparison, Marchette (1985) conducted a survey illustrating that nurses in the United States lost 750,000 working days a year as a result of back pain, twice the national average, when compared with other occupations.

The most frequent type of event producing low back pain in nursing is overexertion associated with actions such as lifting, bending and pulling (Levitt, 1971; Snook, 1978; Johnston, 1982; Raistrick, 1981; Harber, 1985; Nestor, 1988). More specifically, low back pain is largely a symptom of, or precipitated by, frequent lifting of patients, while the patients are either in or close to the hospital bed.

Pheasant (1987) indicated that patient handling tasks (lifting) are extremely hazardous according to the National Institute for Occupational Safety and Health (NIOSH) criteria. Patient handling tasks exceed the Action Limits (AL) and the Maximum Permissible Limits (MPL) for lifting. To a lesser extent, high levels of postural stressors, such as walking, standing and stooping, are responsible for low back pain (Garg, 1991).

The work of nursing is quite varied, including many separate physical tasks. Since the nursing practice involves working with injured or sick human beings, special problems are imposed (eg. patients can be unpredictable and suddenly resist movement). Stubbs (1983) noted that it is difficult to apply lifting standards imposed by existing legislation, in that some of the lifting done by nurses is in an emergency situation, where the basic rules of training, which include the desirability of summoning help, is not always appropriate.

Moving/handling a patient can be difficult, at the best of times, according to Harber (1985). Physical obstructions (via tables, chairs, cabinets, etc) to patients and fragile, extended attachments to patients (eg. intravenous bottles and stands) are frequently observed problems associated with moving/handling a patient. Manual handling of patients is a skilled activity that requires time, practice and application in order to be executed in a safe and comfortable manner. Not only must heavy loads (eg. heavy patients) be lifted, but the shape of the load is inefficient for lifting; the body mass is not compact with convenient handholds. Although mechanical assisting devices are available to nurses when required, assistance by a second staff member is usually the most common method implemented (Harber, 1988).

In summary, several studies conclude that nursing personnel show a relatively high prevalence of occupational low back pain (as a result of lifting injuries), associated with a substantial health care recovery cost. Furthermore, members of the nursing profession have identified occupational low back pain as an inevitable part of the nursing practice (Harber, 1988). A report from the Royal College of Nursing (1979) stated that low back pain has been and is still regarded as an occupational hazard of nursing.

Physical Demands of Nursing

Although minimal research is available on the physical demands of nursing, Ljungberg (1989) and Dehlin (1974) have assessed some aspects of the physical demands of nursing. In both studies, nursing aides (NA) were assessed as opposed to registered nurses (RN). In light of the economical times, RNs and NAs are participating in many of the same physical nursing tasks during a work shift, and therefore these two studies may be considered relevant.

In 1989, Ljungberg studied 24 nursing aides (18 women and 6 men) at one traditional and one modern geriatric ward, and warehouse workers (16 men), during occupational work. Strain gauges were placed into the wooden shoes of the NAS and warehouse workers, to measure the vertical load during manual handling. Heart rate, pulmonary ventilation and oxygen uptake were also intermittently assessed during occupational work.

When analyzing the tasks of the NAS, grouping the two geriatric wards together, the following was completed; a) 22 (±11) lifts/hour, b) 189 (±164) seconds of lifting/hour, c) 2202 (±676) steps per hour, d) 83 (±73) steps/hour, during lifting, e) a heart rate of 100 (±10) beats/minute, f) pulmonary ventilation of 17.8 (±2.5) litres/minute, and g) oxygen uptake of 0.59 (±0.10) litres/minute. When comparing these results with warehouse workers, the warehouse workers performed four times as many lifts and transferred five times as great a mass per unit time. On the other hand, the NAs were exposed to lifts and carries of longer duration and also to a greater frequency of unexpected, sudden and high peak loads. The heart rate and oxygen uptake values, for both occupations, were relatively low and not taxing on the circulatory system.

Differences were apparent when comparing the physical tasks of the NAs of the two geriatric wards. Most importantly, lifting work was approximately 50% less on the modern ward.

Dehlin (1974) assessed the circulatory load on NAs (18 females) during the course of a working day. Since heart rate is a good indicator of the work load, the heart rate was recorded every minute, via telemetry, while the NAs were working. Approximately 40% of all heart rate recordings, in the group of NAs, were between 90-105 beats/minute. Thirty percent of the heart rate recordings were between 75-90 beats/minute and approximately 20% were between 105-120 beats/minute. The average heart rate during duty hours ranged between 78 and 110 beats/minute. The oxygen uptake of four frequently used NA tasks, was also assessed; storing linen was the most physically demanding (4.1 kcal/min.) while walking a patient was the least physically demanding (2.0 kcal/min.). The average demands on circulation and energy during NA work were found to be similar to those in domestic and light industrial work (ie. flight attendant).

Further research is warranted in this area, to fully identify and understand the physical demands of nursing.

Measurement of Trunk Muscle Performance

During the last 15 years, a variety of researchers have been investigating trunk muscle performance. The proliferation of literature associated with trunk muscle performance is partially due to the increasing sophistication of isokinetic equipment (Beimborn, 1988). Research on isometric, isotonic and isokinetic testing of the back extensors and flexors has been reported both concentrically and eccentrically utilizing either athletic, healthy or low back pain subjects. Unfortunately, information on trunk muscular strength and endurance, with regards to occupations, especially of women, is not available.

Early methods for testing trunk strength are primitive and of an isotonic nature. The Rogers Physical Fitness Index (PFI), of 1926, was one of the earliest evaluations of trunk strength documented. Other traditional methods used to evaluate trunk strength include the number of sit ups or spinal extension arches completed and single maximal concentric contraction against a weight resistance (i.e. one repetition maximum). Such methods have recently been questioned as to their validity. Moffroid (1986), conducted a study in which subjects were randomly assigned to either an exercise group or a control group. Twice a day, for six weeks, the exercise group performed trunk curls or partial sit ups. Post-treatment analysis indicated there was no significant difference between the exercise and control groups, with regards to trunk flexor strength. In 1987, Smidt concluded double leg raises, sit ups and prone trunk extensions were poor discriminators of trunk strength. The preceding evaluations of trunk muscle strength can only be used as indicators of trunk flexion and extension strength because maximal trunk strength can only be recorded at the weakest point in the range of motion due to physiological and biomechanical factors.

More recently, isometric back strength has been aggressively investigated due to the advent of strain gauges (e.g. the Harness strain gauge (Addison, 1980; McNeill, 1980)), cable tensiometers (e.g. the Harrison Clark Cable Tensiometer (Alston, 1966)), modified dynamometers (e.g. the Dynamometer I (Asmussen, 1959)), and scales. Subjects are positioned in the neutral, upright position or at different points in the range of motion (Beimborn, 1988). Isometric strength tests are easy to standardize and safe to conduct, as long as the subject is instructed to keep breathing (as normally as possible) while performing the isometric contraction. Chaffin (1974) and Hansson (1983) both identify isometric testing as being safer than dynamic testing because they are less time consuming, less fatiguing to the subject and the testing movement is in a safe range of motion.

Today, trunk muscular strength is being isokinetically tested through the entire range of the trunk motion, at various predetermined velocities, in a variety of positions; lying (Hasue, 1980), standing (Rowland, 1988 ; Marras, 1984) and sitting (Nordin, 1986 ; Langara, 1984). Through isokinetic testing, maximal force is applied (by the trunk) to the dynamometer arm over a predetermined range of movement. The resistance of the dynamometer is therefore an indicator of the muscular strength and endurance of the trunk at different joint angles. Examples of the measuring instruments include the Cybex II Isokinetic Dynamometer (Beimborn, 1988: Davies, 1982), the Prototype Isokinetic Torso Rotational Unit (Mayer, 1985) and the Iowa Force Table (Smidt, 1980). The Kinetic Communicator or Kin-Com Isokinetic Dynamometer, with the back attachment, (Chattex Corporation, Chattanooga, Tennessee) is also used to assess trunk performance but few references are available (Fenety, 1989; Wessel, 1988). This system can measure torque produced by isometric, concentric and eccentric contractions.

Accurate analysis of the concentric torque representative of performance of the trunk muscles have been achieved (Davies, 1982; Smidt, 1980). Analysis of the eccentric torque representative of performance of the trunk muscles is in it's infancy and therefore has yet to be perfected.

Most researchers agree that a unique set of effects or confounding variables associated with isokinetic apparatus need to be addressed when testing isokinetically :

a) Overcoming Inertia (Inertial Effects)

Since isokinetic testing is dynamic in nature, and occurs at a variety of speeds, the torque output produced by the muscle group may contain a prominent initial spike, which might be followed by torque oscillations of decreasing amplitude (Sapega, 1982). The higher the velocity of testing, the more prominent the initial spike. Baltzopoulos and Brodie (1989) describe the 'torque overshoot' artifact as occurring early in the movement and is either the reaction of the dynamometer to the overspeeding limb (the limb overcoming the inertia of the dynamometer lever arm) or a jerking movement of the limb, during testing. Muscular strength and endurance of the muscle group tested will be overestimated if the researcher chooses the torque overshoot artifact to represent the subjects' maximum force (or peak torque).

b) Effects of Gravity (Gravitational Error)

When testing movements in the vertical plane isokinetically, the forces acting on the dynamometer lever system are muscular (generated by the muscle group being tested) and gravitational (generated by the mass of the limb and the lever arm through out the range of motion) in nature. The recorded torque is therefore, a resultant of the torque generated by muscular and gravitational forces. Since the gravitational force remains constant (for the same testing conditions) and is dependant upon the magnitude of the muscular force applied, it is possible to eliminate the 'gravitational error' via correctional equations. The Kin-

Com, for example, intrinsically corrects for the effects of gravity prior to producing and printing results. Some researchers choose to eliminate the effects of gravity on the recorded torque(s), while others do not.

c) Angular Position

Biomechanical information about the working muscles are provided by the angular position(s) of the joints. Since isokinetic testing can determine the optimum joint angle needed by the muscle (or muscle group) to produce maximal force, it is essential that the researcher isolate and stabilize the joint (or body part) being tested. Elaborate and exact documentation, regarding joint stabilization, needs to be conducted.

Women and the Measurement of Trunk Muscle Performance

Although a proliferation of investigations regarding back muscular strength and endurance have been conducted during the last 15 years, only a limited number of studies have included female subjects. The following is a brief list of selected studies concerning trunk (back) muscular extension strength in healthy, adult women;

1. In 1969, Nachemson was one of the first researchers to analyze the isometric concentric trunk extension strength of women. Twenty females (20-35 years of age) were tested in the standing and lying positions, on the

Zadig dynamometer. The average standing isometric torque (over three determinations) was reported to be 453 N, whereas the average lying isometric torque was 469 N. For both testing positions, the mean angle at which the average of the isometric torques were performed, was not identified.

2. Addison (1980) and McNeill (1980) measured the isometric concentric trunk strength, of 30 females (from a standing position), using the Harness strain gauge. Isometric concentric trunk extension torque was identified as being 347 N. The mean angle at which the average trunk extension torques occurred was not recorded.

3. In 1980, Hasue investigated the isometric and isokinetic, concentric contractions of the back muscles of fifty women in the prone position. In order to measure the strength of the trunk muscles, a specially designed bar was connected to the lever arm of a Cybex dynamometer. The bar was positioned just below the scapula when measuring the back muscles. The results from the analysis were reported in age increments of 10 years. The mean values of isometric concentric trunk extension muscular strength ranged from 91 to 150 N (the angle(s) at which the isometric trunk contractions occurred were not identified).

The mean values of isokinetic concentric trunk extension muscular strength ranged from 75 to 120 Nm. Isokinetic testing was performed at 6°/second, and the range of trunk motion was not predetermined.

Maximum isometric strength levels were achieved in the age range of 30 - 39 years of age, overtaking the age range of 20 -29 years of age. Although the authors did not address why the older female group appeared stronger than the younger female group, occupation, lifestyle and physical fitness level may have influenced the results.

4. In 1983, Smidt analyzed the trunk performance of 12 females, isometrically and isokinetically, using the Iowa trunk dynamometer. The average prone isometric trunk torque, for the subject group, was 200 N. The average side lying isokinetic concentric trunk torque, at 30 er second, was 160 Nm.

5. In 1984(a), Langrana analyzed the trunk muscle performance of 26 female volunteers. Each subject was seated in a Cybex II dynamometer. By having the subject in a seated position, the contribution of the pelvic girdle (including the iliopsoas muscle) and the lower extremity muscles to the total torque output, was minimized. Isokinetic back concentric extension torque, at 30° per second, was recorded at 98 (±46) Nm. Isometric back concentric extension torque was recorded at 123 (±57) N. The mean angle at which the average of

the peak trunk extensor concentric torques occurred, for both isometric and isokinetic contractions, were not documented. Back muscular fatigue was also assessed and indicated that women have lower maximal strength but possess equal or better endurance than men. Testing, in the sitting posture, was found to be more tolerable than testing in the standing posture. The researcher concluded that back strength testing in the sitting posture was both effective and safe.

6. Nordin (1987) assessed the back muscular strength and endurance of 101 healthy females, ages 18-48 years. The subjects underwent a test battery that included Cybex II isometric and isokinetic strength testing of the back muscles. Seated isokinetic concentric trunk extension torque, at 30° per second, was 122 (±40) Nm, with a range of 52-234 Nm. The angle of peak torque was 32 (±17)°, with a range of -20° to 64°. Prone isometric concentric trunk extension torque was 98 (±23) N, with a range of 38-160 N.

7. In 1989, Fenety isokinetically analyzed the trunk muscular strength of 11 healthy, physically active, university females and 12 university, varsity, female, field hockey players, using the Kin-Com dynamometer. Each subject was tested in a seated position, at 60° per second. Although the testing protocol differed from this study, subject body alignment, on the Kin-Com, was

very similar. Group mean trunk extensor concentric and eccentric peak torques, for the healthy, university females, were 228.9 (±11.6) Nm and 270.9 (±13.1) Nm, respectively. Mean trunk extensor concentric and eccentric peak torques, for the university, varsity, female field hockey players, were 201.3 (±12.8) Nm and 233.5 (±11.1) Nm, respectively. The mean angles at which the average of the peak trunk extensor concentric troques and the average of the peak trunk extensor eccentric torques occurred, for both subject groups, were not documented.

The average torque for the concentric and eccentric trunk extensions, over four maximal repetitions, were 143.3 (±6.3) Nm and 189.3 (±7.3) Nm, respectively, for the field hockey players. The average torque for the concentric and eccentric trunk extensions, over four maximal repetitions, were 115.6 (±8.0) Nm and 212.0 (± 9.6) Nm, respectively, for the healthy, university students.

In summary, several studies have effectively analyzed the back muscular strength (especially the back concentric extensor strength) of women. Unfortunately, comparing the results of these studies can be a difficult task. Most studies appeared to use different assessment instruments, body position and protocols. The only consistent factor, across all studies, was the use of healthy, normal women as test subjects. Therefore, it is not surprising to discover that these studies produced a variety of different back strength values. Unfortunately, for the purposes of the current study, most researchers did not a) make any reference to the occupational groups to which the women belonged, b) use the Kin-Com dynamometer, c) identify the trunk angle at which the trunk extensor peak concentric/eccentric torques occurred, and d) analyze the back eccentric muscular strength and endurance. Only a few of the aforementioned studies assessed the trunk performance isokinetically.

Characteristics of the Trunk Muscles

The trunk extensors, or the back muscles, consist of the erector spinae muscle group (the spinalis, the iliocostalis and the longissimus) and are, at times, assisted by a powerful, deeper layer muscle, the multifidus. The multifidus, a complex uni-segmental muscle, rotates vertebra segments and prevents pinching of the capsule as the facet joints close in extension and rotation. The trunk flexor muscles, on the other hand, consist primarily of the obliquuis internus and externus and the rectus abdominus.

In general, the trunk, especially the back muscles, are involved in many every day activities, concentrically, eccentrically, and isometrically. For example, when lifting an object, in an upward direction, the initial phase of the action, to overcome the forces of the movement, involves both isometric and concentric contractions of the back muscles. By comparison, lowering an object, in the downward direction, involves eccentric contractions. Holding an object in mid-air requires isometric contractions of the back muscles.

Trunk muscles (both extensors and flexors) have two basic functions; a) to assist in stabilizing and moving of the trunk and b) to assist in maintaining a proper posture.

The vertebral column, the central, bony stabilizer of the trunk, exquisitely combines the demands of strength and flexibility. Cailliet (1981) divided each vertebrae into two segments; the anterior vertebral body and the posterior vertebral body. Together, these two segments, form a 'functional unit'. The anterior vertebral body is a supporter, weight-bearer, and shock absorber for the human body. The posterior vertebral body is a protector of the spinal cord and a director of movement within the functional unit. Farfan (1985) indicated bending of the trunk is a two-part movement (involving both the spine and pelvis), whereby lumbar flexion/extension accounts for approximately the first 60 degrees of movement.

Most authors agree trunk extension force is greater than trunk flexion force, when analyzing trunk muscle strength data (Hasue, 1980; Davies, 1982; Langrana, 1984; Beimborn, 1988). Smidt (1983) also identified trunk flexors to fatigue faster than trunk extensors due to the dominance of the fatigue resistant fiber type in extensor muscles. Johnson (1973) has identified these muscle fibers as slow twitch oxidative (Type I) fibers.

Few studies concerning the endurance capacity of the back muscles are to be found in the literature (Jorgensen, 1970; Troup, 1981; Biering-Sorensen, 1984; Langrana, 1984). Jorgensen (1987) identified trunk extensor endurance as an important occupational demand in modern technological work in which repetitive motion tasks are performed in fixed and constraint postures. Low back pain appears to affect the trunk extensors to a greater degree than the trunk flexors (Addison, 1980; McNeill, 1980; Nicolaisen, 1985; Mayer, 1986). Recent studies, both prospective and retrospective, demonstrate the frequency of low back trouble to be higher in groups with low static endurance capacity of the trunk extensors (Biering-Sorensen, 1984 ; Nicolaisen, 1985; Vinterberg, 1985). Although the physiological mechanism behind this is unknown, Jorgensen (1987) postulated that individuals with low muscular endurance of the back muscles are more exposed to postural stress that may lead to incorrect loading of the spine and consequently low back trouble.

The second function of the trunk muscles, posture, is an important consideration, particularly in view of today's lifestyle which is very sedentary and mechanically-aided.

With the advent of many physical labour saving devices and sedate working practices, poor postural habits can lead to tremendous backaches and eventually long term disabilities. Ultimately, pronounced slouching can lead to anatomical deformities of the spine.

Weak trunk muscles coupled with poor posture can produce a lowered capacity to a) brace against excessive spinal segment motion, b) prevent ligamentous and capsular sprains and withstand and c) control loads during daily activities (Smidt, 1989).

Occupational low back pain research has been conducted in the form of control approaches, including pre-employment roentgengrams, strength testing, job design and worker training. For strength testing to be of any significance in industry, the strength tests must simulate elements of the job as closely as possible, in order to avoid potential discrimination (Snook, 1988). Pytel (1981) and Kamon (1982) advocate dynamic strength tests as opposed to static strength tests.

Nursing is an occupation that demands a significant amount of lifting. Thus, trunk extensor strength and endurance are important factors, especially to off-set the risk of experiencing occupational low back pain. Proper body mechanics and proper lifting techniques are, at times, difficult to employ. Owen (1987) indicated the condition of the patient, the width and height of the bed, and the location of the side rails are a few of the variables that influence the vulnerability of the nurse when maneuvering patients. Therefore, muscular strength and endurance of the trunk extensors becomes imperative as a key physical performance factor.

CHAPTER III

METHODS AND PROCEDURES

Research Design

This study was designed to be descriptive in nature. The fundamental purpose of descriptive research is to describe characteristics or variables in populations by directly examining samples (Smith, 1987).

Subjects

Seventy-nine female registered nurses (RN), between the ages of 19 and 58 years, from five Edmonton area hospitals, volunteered to participate in the study. Female RNs who a) had experienced low back pain within the last twelve months, b) had ever experienced a disc or neural problem, c) had ever required surgery to repair a vertebra, and d) were pregnant were excluded from participating in the study. All subjects were asked to refrain from vigorous activities twenty-four hours prior to the testing session, and avoid smoking, intake of caffeine and eating two hours prior to the testing session. Each subject completed an informed consent (Appendix B) and a modified Physical Activity Readiness Questionnaire (PAR-Q) (Appendix C) prior to testing. Confidentiality of the results and withdrawal from the study, at any time, were guaranteed.

Recruitment efforts were focused on the University of Alberta Hospitals (U of A H) RNs due to the proximity of the testing facility to these hospitals. The advantage of this proximity was that the U of A H RN's were easily tested before, during or after working shifts. Recruitment advertisements were sent through the U of A H internal electronic mail system (Appendix A) (ensuring each U of A H RN would read the advertisement), on three different occasions. The advertisements were also posted at unit stations and displayed (at a booth) during the Annual International Nurses' Week. Additional recruitment advertisements were sent to other Edmonton area hospitals (approx. 10 other hospitals) in order to recruit a larger sample.

Time Commitment and Risks

Each subject was asked to commit approximately 30 to 35 minutes for testing purposes. Each subject was also notified that secondary muscle soreness, as a result of the eccentric muacle contraction phase, may be experienced immediately or up to 48 hours after the testing session (with peak secondary muscle soreness occurring 24 hours after the testing session). When a proper warm up is performed, chances of injury are decreased. Numerous studies, using isokinetic dynamometry, identify minimal risk to the subject during analysis of trunk muscle performance (Langrana, 1984a).

Subject Confidentiality

Confidentiality was maintained throughout the study; with the test data, stored under code, known only to the investigator. Each subject was provided with a personal report of their results upon completion of the study. All data for future publication will remain coded to ensure subject anonymity. Subjects photographed during the testing session, signed a Research Photograph Release Form (Appendix D) prior to testing. The Research Photograph Release Form indicated that if the photographs were used in a publication or public presentation, the subject would only be identified visually and not by name.

The Instrument

The Kinetic Communicator or Kin-Com isokinetic dynamometer (model 500-9), with the back attachment, was used to assess trunk muscle performance. The Kin-Com exercise system is a hydraulically driven (by a 5 horsepower motor), micro-computer-controlled device for the testing, measurement and rehabilitation of human joint function (Farrell, 1986) (refer to Photo 3.1). The machine-controlled movement modes include isokinetic, semi-isotonic, and isometric. The lever arm speed is continually adjusted to

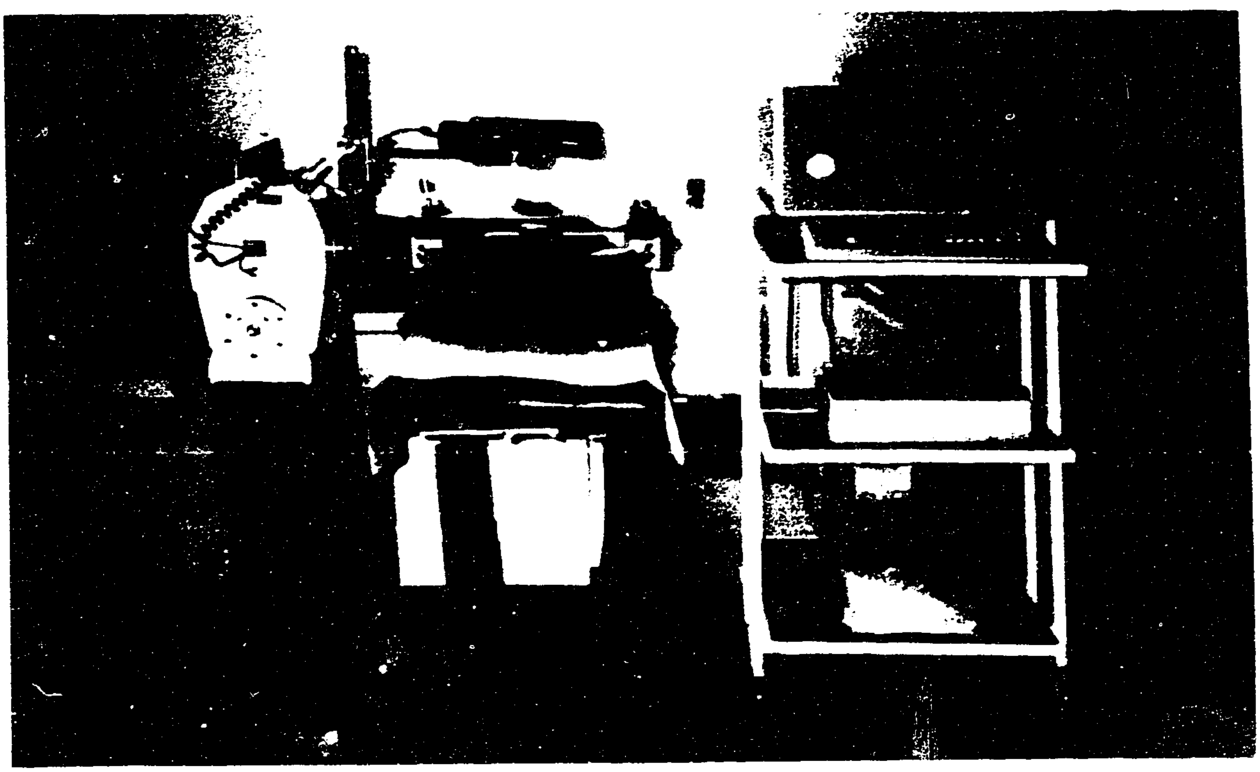


Photo 3.1 Kin-Com Isokinetic Dynamometer and Computer

maintain constant resistance, while working in these modes. Passive joint movement can also be utilized. The system allows for concentric, eccentric and passive joint range of motion to occur from 2 to 300 degrees per second with a peak torque limit at 609.76 Nm (450 ft.lb). The Kin-Com is also designed to compensate for the effects of gravity (correct for gravitational error) generated by the mass of the limb and the lever arm throughout the range of motion. In order to compensate for the effects of gravity, the body part, that is to be assessed, must be weighed (ie. in this study, using the Kin-Com and the back attachment) prior to data collection.

The Kin-Com dynamometer is controlled through feedback loops which monitor the position and speed of the lever arm and the force being exerted by the user. The device utilizes a load cell for force measurement and a bar-encoded shaft for position and velocity measurements. For a detailed description of the Kin-Com (model 500-9) dynamometer, refer to the operation manual (Chattex Corporation, 1986).

Farrell (1986) reported the reliability and validity of the Kin-Com dynamometer operation systems to be from 0.94 - 0.99. Reliability and validity testing, during Farrell's study, focused on the three primary functions of the unit: the lever arm position, the lever arm velocity and the force measurement systems. The forces, created statically by standardized weights and isokinetically by a spring driven system were measured by an external load cell and compared to the Kin-Com measurements. The average difference between the force measurements was 3.2%, the lever arm speed was within 1.5% of the pre-set speed, and the lever arm position showed no differences.

Calibration of the Kin-Com

Pre and post calibration of the Kin-Com dynamometer lever arm position, lever arm speed and force measurement systems were not conducted during data collection, on the advice from an authority on the instrument. Calibration of the Kin-Com, with a known load, was conducted on two separate occasions, January, 1992 and mid-February, 1992. All of the February values were within 1% of the January values. For a complete description of the calibration procedure, refer to the Kin-Com operation manual (Chattecx Corporation, 1986). Calibration of the interface between the computer and the exercise arm was conducted on a daily basis. In addition, the investigator was responsible for checking for defects in the apparatus or materials on a daily basis.

Physiological Testing

Demographic Data Collection

Prior to physiological testing, weight, height, age and years of experience as a R.N. were recorded.

Initial Warm Up

A predetermined warm up was conducted prior to positioning the subject on the Kin-Com dynamometer. The warm up consisted of a) two modified hurdler stretches to each side (each stretch was held for approximately 20 seconds), and b) two forward flexions and two back extensions from the standing position (each flexed or extended position was held for approximately 10 seconds).

Alignment and Positioning of Subject on the Kin-Com

Each subject was positioned in the center of an adjustable seat, in front of the back attachment frame, which was fastened to the Kin-Com dynamometer table (refer to Photo 3.2). The pelvis was stabilized posteriorly with a pad against the sacrum and anteriorly with two curved anterior pelvic pads, thus stabilizing the pelvis (in a neutral position) and minimizing hip involvement. The legs were stabilized, via velcro straps attached to the table, in approximately 90° of flexion. The center of rotation of the Kin-Com lever arm was aligned with the highest point on the iliac crest in the mid coronal plane of the trunk. Vertical displacement of the lever arm, from the center of rotation, was measured and entered into the computer. The pressure pad (containing the load cell), which the subject pushed against or resisted, was aligned around the fifth thoracic (T5) vertebra and below the bony protrusion of the scapula. For a

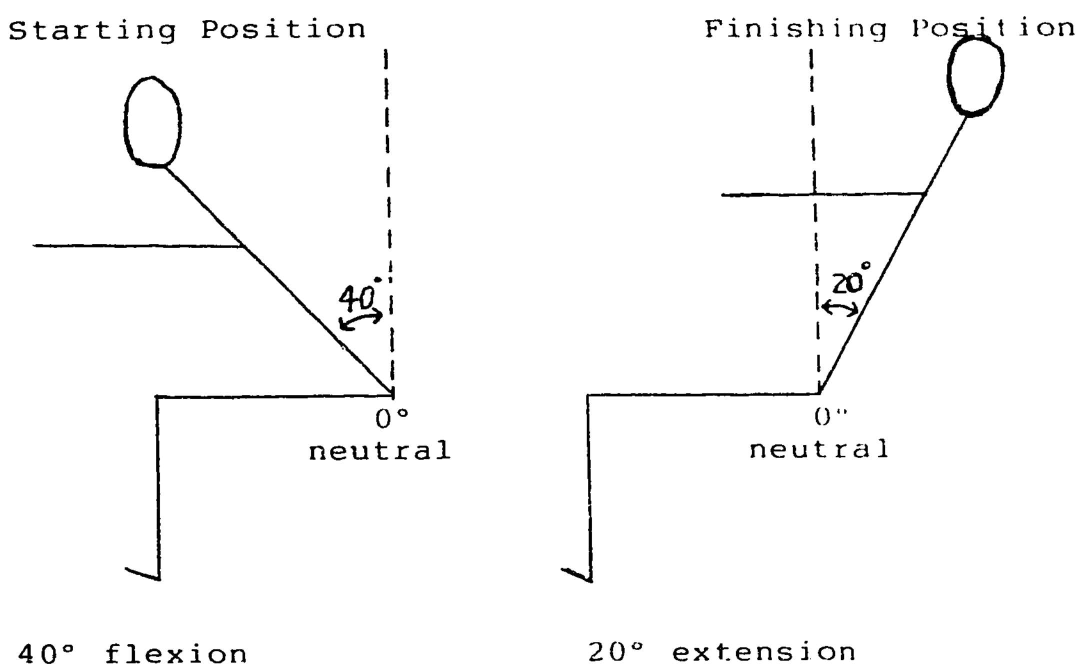
Photo 3.2 Subject Alignment and Positioning on the Kin-Com

detailed description of subject alignment and positioning, refer to the Kin-Com operation manual (Chattex Corporation, 1986).

Once each subject was aligned and positioned on the Kin-Com, the trunk was weighed. Each subject was positioned at 20° of trunk extension and instructed to relax, rest the trunk on the pressure pad (connected to the lever arm) and let their arms hang to the side. When the subject exhaled, the investigator initiated the Kin-Com to weigh the trunk. The weight of the trunk was then programmed into the Kin-Com micro computer. Thus, each subject's testing results would be compensated for the effects of gravity (corrected for gravitational error), prior to printing the results.

Trunk Extensor (concentric and eccentric) Strength Testing Protocol

During the testing session, the spinal range of motion was programmed for 60°; from 40° flexion to 20° extension (refer to Diagram 3.1). The angular velocity was programmed for 30°/second (0.5236 rad/s). When the subject was aligned and positioned (according to the instructions above), she was asked to move to the starting angle (40° flexion) (refer to Photo 3.3). The subject was instructed to push against the pressure pad, at a submaximal voluntary contraction level (approximately 50 % of MVC), until 20° of extension was reached (completing a concentric trunk extension). After



Range of Trunk Motion - 40° flexion to 20° extension

Diagram 3.1 A Simplified Diagram of the Starting Trunk Muscular Strength and Endurance Test Position (40° flexion) and the Finishing Trunk Muscular Strength and Endurance Test Position (20° extension)

Photo 3.3 Subject Positioned at the Starting Angle (40° trunk flexion) of the Trunk Extensor Muscular Strength and Endurance Tests

a pre-set 0.5 of a second stop, at 20° extension, the subject was instructed to resist submaximally against the pressure pad as the pressure pad attempted to push the subject back to the starting angle, completing an eccentric trunk extension.

The first set of three continuous repetitions of concentric/eccentric contractions constituted a warm up. During the warm up and actual strength testing, the subjects were asked to a) maintain a regular breathing pattern, b) focus their eyes on an object in front of them and stick the chin out as they moved through the predetermined range of trunk motion, and c) position the hands together in front of the torso, making sure that the elbows did not come in contact with any part of the Kin-Com dynamometer attachments (Photo 3.4). Since both the Kin-Com dynamometer and eccentric trunk extensions were unfamiliar to the subject, the warm up set allowed the subject to partially familiarize herself to the movement patterns and contraction types prior to the actual data collection.

Two minutes after the warm up contractions, a set of 3 voluntary maximal concentric/eccentric contractions were performed. The subject was instructed to start exercising when she heard the Votrax Type-N-Talk and/or the investigator commence the test. The subject was also instructed to go as hard and as fast as possible until the Votrax Type-N-Talk, on the Kin-Com console, instructs her to

Photo 3.4 Lateral View of the Starting Position of the Trunk Extensor Muscular Strength and Endurance Tests (emphasizing the subject arm position)

stop exercising. Each subject had to produce a contraction measuring at least 50 Nm, in order for the contraction to be registered by the computer. A two minute rest (in a comfortable seated position) was given prior to a second set of 3 voluntary maximal concentric/eccentric contractions.

Trunk Extensor (concentric and eccentric) Endurance Testing Protocol

Alignment and positioning for this test was the same as previously cited for the trunk extensor strength testing.

Testing range of motion was 60° : from 40° flexion to 20° extension. The angular velocity was programmed for 30°/second (0.5236 rad/s). Following the 2 sets of maximal voluntary contractions (from the strength testing), a two minute rest, in a relaxed seated position, was permitted.

During the endurance test, the subjects were instructed to a) start exercising when they heard the Votrax Type-N-Talk and/or the investigator commence the test, b) perform continuous concentric/eccentric trunk extensions for approximately 90 seconds (corresponding to 20 repetitions of each type of muscle contraction), c) maintain a regular breathing pattern, d) focus the eyes on an object in front of them and stick the chin out as they moved through the trunk range of motion, e) position the hands together in front of the torso, making sure that the elbows did not come in contact with any part of the Kin-Com dynamometer attachments, f) perform each muscular contraction at a voluntary maximal level and g) stop exercising when commanded by the Votrax Type-N-Talk on the Kin-Com console (Photo 3.4).

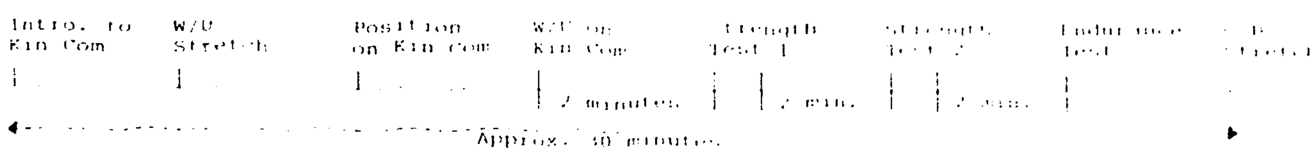
The testing session was concluded with a cool-down stretch consisting of two modified hurdler stretches on each side, held for 20 seconds duration.

All subjects were tested in the same order (refer to Diagram 3.2). A pilot study using ten, healthy subjects was conducted prior to thesis data collection, in order to refine the physiological assessment methodology.

Reliability

Reliability of the trunk extensor strength and endurance testing protocol was conducted using the test-retest method. Eight healthy females were retested on non-successive days (within 48 hours of the first testing day) using the identical protocol. Pearson product moment correlation coefficients were calculated between Day 1 and Day 2 maximum/peak values for the reliability subject group.

Althoughfemale RNs were not used to assess the reliability of the testing protocol, reliability coefficients were analyzed for the assessed variables between Trial 1 and Trial 2 of the strength testing protocol. The probability level for all of the correlation analyses was pre-set at $p<.05$.



W/U - Warm up, C/D - Cool down

Diagram 3.2 Time Sequence of Physiological Testing

Analysis of the Data

Descriptive statistics including, mean, standard deviation, standard error, minimum value, and maximum value were computed for subject group characteristics, and trunk extensor muscular strength and endurance variables.

Overcoming inertia and the effects of changing from a concentric contraction to an eccentric contraction, have an effect on concentric peak torque (CPT), concentric angle of peak torque (CAPT), eccentric peak torque (EPT), and eccentric angle of peak torque (EAPT) (Sale, 1991; Fenety, 1989). To account for these effects, the above variables were analyzed at a window range of 50°. Five degrees were eliminated from the start and finish angles, thus the data was analyzed from 35° flexion to 15° extension (refer to Diagram 3.3 and 3.4).

Normative data was compiled into tables of percentile rankings where the median represented the 50th percentile for the following recorded values:

1. maximal (peak) isokinetic concentric trunk extension strength
2. angle of peak isokinetic concentric trunk extension torque
3. maximal (peak) isokinetic eccentric trunk extension strength
4. angle of peak isokinetic eccentric trunk extension torque

5. percentage that (peak) maximal isokinetic concentric trunk extension strength was of maximal (peak) isokinetic eccentric trunk extension strength
6. computer average (of three maximal, voluntary contractions) isokinetic concentric trunk extension strength
7. computer average (of three maximal, voluntary contractions) isokinetic eccentric trunk extension strength
8. total work completed by the 20 isokinetic concentric trunk endurance extensions
9. total work completed by the 20 isokinetic eccentric trunk endurance extensions
10. muscular fatigue index for the 20 isokinetic concentric trunk endurance extensions
11. muscular fatigue index for the 20 isokinetic eccentric trunk endurance extensions

Development of the percentile ranking tables was based on the procedure outlined by Olson (1987). The general procedure involves three steps;

a) arrange the observations (or raw scores), of each tested/calculated variable, in ascending or descending order,

b) determine where in the desired interval the required percentile falls. In the case of this study, each 5 percentile increment represents 3.95 subjects (ie. if 100

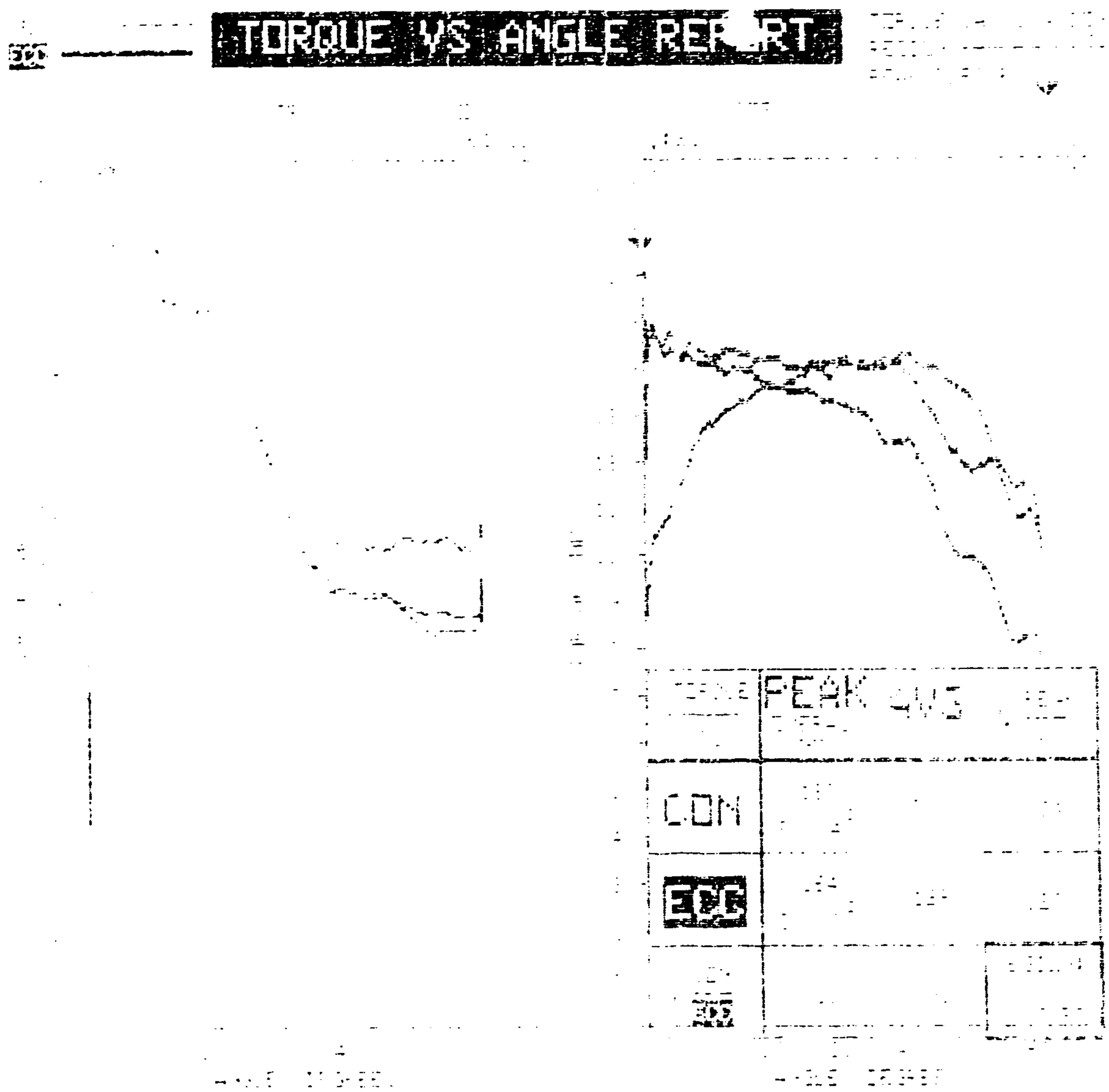


Diagram 3.3 An Example of the Kin-Com Computer Print Out from the Trunk Extensor Muscular Strength Test

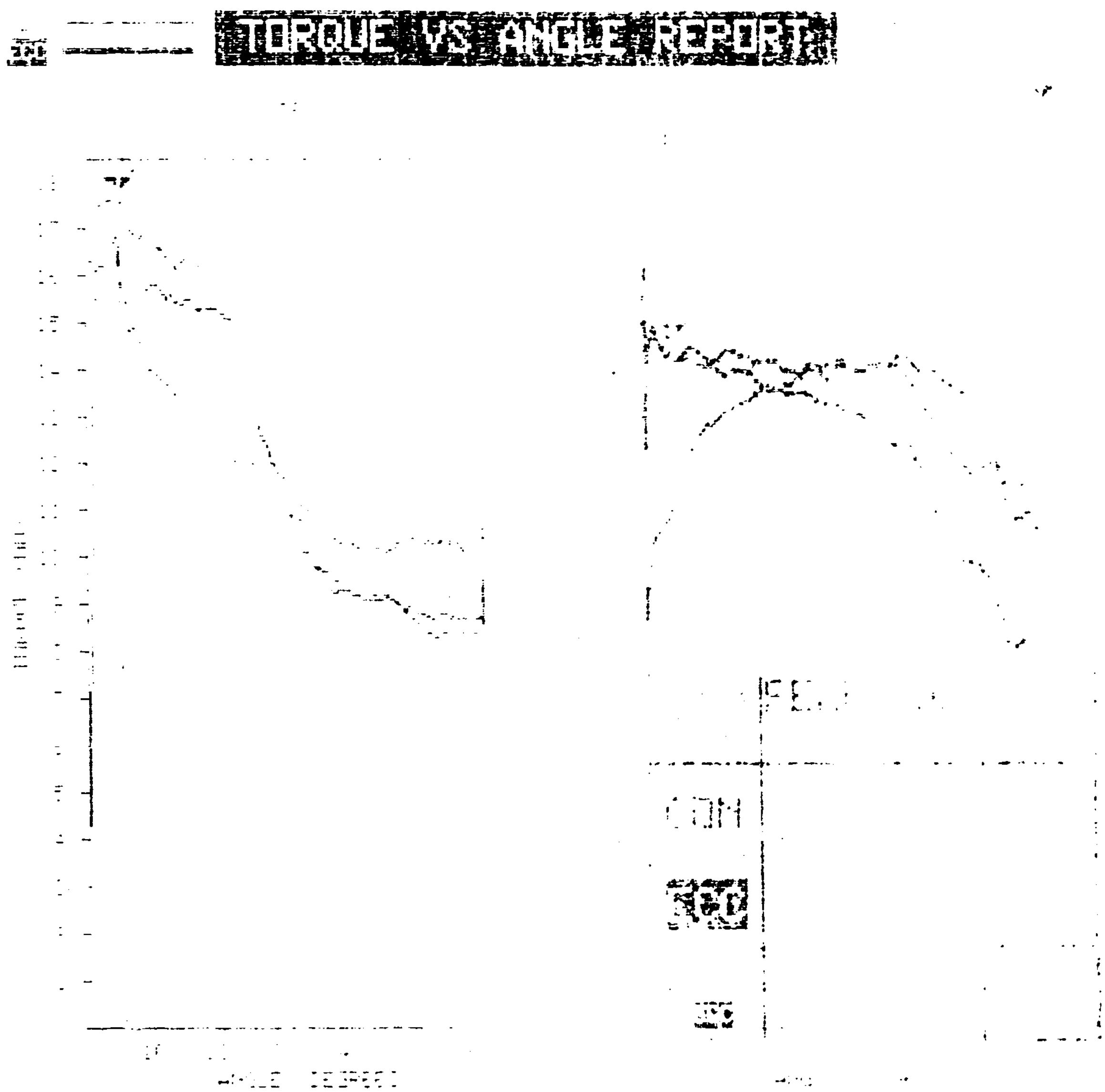


Diagram 3.4 An Example of the Kin-Com Computer Windowed Print Out from the Trunk Extensor Muscular Strength Test

subjects were tested, each 5 percentile increment would represent 5 subjects).

c) If the interval contains more than one observation (ie. 2 or more RNs produced the same score), then determine what portion of the way through that interval one must go to reach the given percentile.

When implementing this procedure, one assumption must be acknowledged: to approximate the quantiles of grouped data, assume that the observations are uniformly distributed within each category. For a complete description of the mathematical steps involved in developing percentile ranking tables, refer to Olson (1987).

CHAPTER IV

RESULTS

Introduction

The major purpose of this study was to analyzed the trunk muscle performance variables of female registered nurses and develop percentile tables for isokinetic concentric and eccentric trunk extensor muscular strength and endurance. In order to achieve this purpose, the variables were organized as follows;

1. A summary of the RN subject group characteristics.
2. The pertinent reliability coefficients for test-retest reliability, including a summary of a) the reliability subject group characteristics, and b) the assessed and computed trunk extensor muscular strength and endurance variables.
3. A summary of the assessed and computed trunk extensor muscular strength and endurance variables.
4. Compilation of percentile tables for assessed trunk extensor muscular strength and endurance variables.
5. Graphical representation (via histograms) of the percentile tables.

Subjects

Seventy-nine female RN's, from the Edmonton area, volunteered to participate in the study. Subject group characteristics, hospital of employment and nursing unit are summarized in Tables 4.1, 4.2 and 4.3 respectively. Seventy percent of the subjects were employed full time (57 RNs), while twenty-seven percent (21 RNs) were employed part time. Only one RN was unemployed at the time of the physiological testing. The mean age of the RN group was 36.6 (±9.5) years of age, while the mean years of nursing experience was 12.4 (±9.1) years.

Table 4.1 A Summary of Subject Group Characteristics (N=79)

	MEAN	S.D.	S.E.	MIN.	MAX.
Age (yrs)	36.6	9.5	1.06	19.0	58.0
Weight (kg)	65.4	11.1	1.25	39.4	93.2
Height (cm)	164.5	54.0	.61	152.0	177.0
Experience (yrs)	12.4	9.1	1.02	.5	37.0

Table 4.2 A Summary of the Edmonton Area Hospitals Which Employed the Subject Group (Edmonton, Alberta)

Hospitals	Number	% of total N
University of Alberta	69	87.3
Royal Alexandra	5	6.3
Alberta Hospital	2	2.5
Grey Nuns	1	1.3
Gov't of Canada (Military)	1	1.3
Unemployed	1	1.3

Table 4.3 A Descriptive Summary of the Nursing Units*

	Number of Nurses (% of total N)
MEDICAL (includes cardiology (5), general medicine (5), infectious disease (3), gastroenterology (2), pulmonary (1), respiratory (1), and urology (1) units)	18 (22.8)
SURGICAL (includes neurosurgery (6), surgical (6), day surgery (5) units)	17 (21.5)
CRITICAL CARE (includes neurology (3), cardiovascular intensive care (6), trauma (3), burn (1), and emergency (1) units)	14 (17.7)
REHABILITATION (includes orthopaedics and spinal cord rehabilitation (8), respiratory home care (2), ambulatory care (1) units)	11 (13.9)
MATERNAL AND CHILD HEALTH (includes paediatrics (4), maternity (3), observation and nursery (1), obstetrics (1), units)	9 (11.4)
OTHER (includes floats (3), psychiatric nursing (3), clinical specialists (2), researchers (1), and unemployed (1))	10 (12.7)

* unit groupings were established using the guidance of a registered nurse and of the nursing unit groupings described by Harber (1985).

Reliability Coefficients for Test-Retest Reliability of the Protocol

Eight healthy females were used to establish test-retest reliability of the trunk extensor muscular strength and endurance protocols. Table 4.4 summarizes the reliability subject group characteristics.

Table 4.4 A Summary of the Reliability Subject Group Characteristics (N=8)

	Mean	S.D.	S.E.	MIN.	MAX.
Age (yrs)	27.1	2.7	1.0	25	33
Weight (kg)	61.8	6.3	2.2	54.6	70.7
Height (cm)	164.9	4.7	1.7	159	174

Tables 4.5 to 4.7 summarize all of the maximum/peak variables that were either assessed or computed (from assessed variables) during Day 1 of the reliability group trunk extensor muscular strength and endurance testing.

Table 4.5 A Summary of the Assessed Maximum/Peak Trunk Extensor Muscular Strength Variables for Day 1 of the Reliability Group (N=8)

	Mean	S.D.	S.E.	MIN.	MAX.
CPT (Nm)	173.3	53.7	19.0	89	237
EPT (Nm)	194.4	51.5	18.2	127	252
CAPT (°)	16.4	16.1	5.7	35 fl	15 ex
EAPT (°)	11.4	10.9	3.9	15 ex	31 fl
% CPT/EPT	89.0	16.1	5.7	66.4	118.2

A = angle, C = concentric, E = eccentric, ex = extension, fl = flexion, P = peak, T = torque, Nm = Newton meters, ° = degree

Table 4.6 A Summary of the Assessed Computer Average Trunk Extensor Muscular Strength of Three Maximal Voluntary Contractions for Day 1 of the Reliability Group (N=8)

	Mean	S.D.	S.E.	MIN.	MAX.
- CT (Nm)	116.0	34.6	12.2	66	167
- ET (Nm)	143.0	33.7	11.9	99	198

C = concentric, E = eccentric, T = torque, Nm = Newton meters, - = average

Table 4.7 A Summary of the Assessed and Calculated Trunk Extensor Muscular Endurance Variables for Day 1 of the Reliability Group (N=8)

	Mean	S.D.	S.E.	MIN.	MAX.
W20C (J)	1795.7	316.4	111.9	1347.9	2237.3
W20E (J)	1809.1	402.3	142.2	1170.0	2388.7
FIC	.80	.17	.06	.60	1.06
FIE	.62	.14	.05	.36	.87

C = concentric, E = eccentric, FI = fatigue index,
J = joules, W = work

Tables 4.8 to 4.10 summarize all of the maximum/peak variables that were either assessed or computed (from assessed variables) during Day 2 of the reliability group trunk extensor muscular strength and endurance testing.

Table 4.8 A Summary of the Assessed Maximum/Peak Trunk Extensor Muscular Strength Variables for Day 2 of the Reliability Group (N=8)

	Mean	S.D.	S.E.	MIN.	MAX.
CPT (Nm)	163.5	35.7	12.6	124	243
EPT (Nm)	168.3	45.0	16.0	130	269
CAPT (°)	12.8	7.9	2.8	35 fl	10 fl
EAPT (°)	16.3	12.2	4.3	15 ex	20 fl
% CPT/EPT	98.5	11.5	4.1	88.1	118.8

A = angle, C = concentric, E = eccentric, ex = extension, fl = flexion, P = peak, T = torque, Nm = Newton meters, ° degree

Table 4.9 A Summary of the Assessed Computer Average Trunk Extensor Muscular Strength of Three Maximal Voluntary Contractions for Day 2 of the Reliability Group (N=8)

	Mean	S.D.	S.E.	MIN.	MAX.
- CT (Nm)	116.1	29.7	10.5	80	179
- ET (Nm)	130.3	39.0	13.8	86	215

C = concentric, E = eccentric, T = torque, Nm = Newton meters, - = average

Table 4.10 A Summary of the Assessed and Calculated Trunk Extensor Muscular Endurance Variables for Day 2 of the Reliability Group (N=8)

	Mean	S.D.	S.E.	MIN.	MAX.
W20C (J)	1901.5	418.2	147.9	1217.4	2393.8
W20E (J)	1972.8	400.3	141.5	1437.9	2656.7
FIC	.83	.21	.07	.62	1.25
FIE	.75	.16	.06	.57	1.05

C = concentric, E = eccentric, FI = fatigue index,
J = joules, W = work

Table 4.11 identifies the complete set of significant Pearson product moment correlation coefficients (p<.05) between Day 1 maximum/peak values and Day 2 maximum/peak values for the reliability group.

Table 4.11 A Summary of the Pearson Product Moment Correlation Coefficients Between Day 1 Maximum/Peak Values and Day 2 Maximum/Peak Values for the Reliability Group

	Day 1 Day 2		Day 1 Day 2
CPT	.749*	- CT	.836*
EPT	.607	- ET	.728*
CAPT	.109	W20C	.928*
EAPT	-.103	W20E	.928*
%CPT/EPT	.484	FIC	.572
		FIE	.439

* significant at p<.05
E = eccentric, - = average, C = concentric, T = torque, A = angle, % = percent, W = work, FI = fatigue index

Although the female RN group was not used to establish test-retest reliability of the trunk extensor muscular strength and endurance protocols, reliability coefficients were analyzed for the assessed variables between Trial 1 and Trial 2 of the strength testing protocol. Table 4.12 displays the complete set of Pearson product moment correlation coefficients. All of the assessed variables were significant at the p<.05 level.

Table 4.12 A Summary of the Pearson Product Moment Correlation Coefficients Between Trial 1 and Trial 2 for the RN's

	Trial 1 Trial 2		Trial 1 Trial 2
CT	.757*	%CT/ET	.676*
CAT	.46*	- CT	.852*
ET	.82*	- ET	.764*
EAT	.401*		

* significant at p<.05
E = eccentric, - = average, C = concentric, T = torque, A = angle, % = percent, W = work

Trunk Extensor Muscular Strength and Endurance Variables

The data in tables 4.13, 4.14 and 4.15 summarize all of the variables that were either assessed or computed (from assessed variables) during the RN trunk extensor muscular strength and endurance testing. All of the 79 RNs completed the strength portion of the testing, whereas 72 RNs completed the endurance portion of the testing. Reasons for not completing the endurance testing included; a) muscular fatigue (2 subjects), b) computer malfunction (2 subjects), c) knee pain from an old ski injury (1 subject), and d) no reason indicated (2 subjects).

Normal distributions were displayed for each assessed or computed variable. Sixty-six percent of each variable's scores were located within one standard deviation of the mean. Ninety-five percent of each variable's scores were located within two standard deviations from the mean.

The data shown in Table 4.13 represents the assessed RN trunk extensor muscular strength variables. The mean CPT was 149.5 (±47.2)Nm, whereas the mean EPT was 198.1 (±54.4) Nm. The mean CPT was identified as representing approximately 76% of the mean EPT.

Table 4.13 A Summary of the Assessed Trunk Extensor Muscular Strength Variables (N=79)

	Mean	S.D.	S.E.	MIN.	MAX.
CPT (Nm)	149.5	47.2	5.3	55	271
EPT (Nm)	198.1	54.4	6.1	97	388
CAPT (°)	25.5	12.4	1.4	35	15 ex
EAPT (°)	8.7	9.9	1.1	15	32 fl
% CPT/EPT	76.2	15.3	1.7	22.2	108.4

A = angle, C = concentric, E = eccentric, ex = extension, fl = flexion, P = peak, T = torque, Nm = Newton meters, ° = degree

The data in Table 4.14 represents the assessed RN computer average trunk extensor muscular strength of three maximal voluntary contractions. The -ET was 134.8 (±36.1) Nm and the -CT was 97.0 (±30.1) Nm.

Table 4.14 A Summary of the Assessed Computer Average Trunk Extensor Muscular Strength of Three Maximal Voluntary Contractions (N=79)

	Mean	S.D.	S.E.	MIN.	MAX.
- CT (Nm)	97.0	30.1	3.4	22	159
- ET (Nm)	134.8	36.1	4.1	68	250

C = concentric, E = eccentric, T = torque, Nm = Newton meters, - = average

Table 4.15 displays a summary of the assessed and calculated RN trunk extensor muscular endurance variables. The mean W20C was 1865.8 (±518.8) J, whereas the mean W20E was 2000.8 (±603.7) J.

Table 4.15 A Summary of the Assessed and Calculated Trunk Extensor Muscular Endurance Variables (N=72)

	Mean	S.D.	S.E.	MIN.	MAX.
W20C (J)	1865.8	518.8	61.1	873.9	3406.2
W20E (J)	2000.8	603.7	71.1	654.0	3488.5
FIC	.98	.25	.03	.55	1.67
FIE	.74	.14	.02	.45	1.22

C = concentric, E = eccentric, FI = fatigue index, J = joules, W = work

Percentile Tables for Trunk Extensor Muscular Strength and Endurance Variables

The data in Tables 4.16, 4.17, 4.18 summarize the percentile rankings demonstrated by the female RN for trunk extensor muscular strength and endurance. The tables are displayed in increments of 5 percentiles with the 50th percentile representing the median achieved by the subject group. Each

increment contains a frequency of approximately 4 female

RNs.

Table 4.16 demonstrates the percentile rankings for the assessed and calculated trunk extensor muscular strength variables. The CPT percentile ranking column demonstrates a median of 142.75 Nm, with a range from 54.50 Nm to 270.50 Nm. The EPT percentile ranking column displays a median of 193.00 Nm, with a range from 96.50 Nm to 387.50 Nm. The median for CAPT column is 31.37 degrees of trunk flexion. The range of CAPT is from 35.50 degrees of trunk flexion to 14.50 degrees of trunk extension. The median for EAPT column was 14.25 degrees of trunk extension, with a range of 15.50 degrees of trunk extension to 31.50 degrees of trunk flexion. The percentile ranking column that summarizes the relationship between CPT and EPT displays a median of 74.89, indicating that the CPT is approximately 74% of the EPT. The range of this relationship is from 22.18 to 108.40. The value of 22.18 indicates that a RN demonstrated a CPT/EPT relationship where her CPT was only approximately 22% of her EPT. The value of 108.40 indicates that a RN displayed a CPT/EPT relationship where her CPT was in fact approximately 8% larger than her EPT.

Table 4.16 Percentile Rankings for the Assessed and Calculated Trunk Extensor Muscular Strength Variables (N=79)

Percentile	CPT (Nm)	EPT (Nm)	CAPT (°)	EAPT (°)	%CPT/EPT
<5	54.50	96.50	35.50(f)	15.50(e)	22.18
5	81.45	122.45	35.47(f)	15.48(e)	53.85
10	88.40	138.73	35.47(f)	15.48(e)	56.38
15	105.71	142.35	35.47(f)	15.48(e)	59.66
20	109.30	146.90	35.47(f)	15.48(e)	64.12
25	120.25	149.88	35.47(f)	15.48(e)	65.35
30	122.85	165.20	35.47(f)	15.48(e)	69.23
35	126.83	170.83	35.47(f)	15.48(e)	70.92
40	130.10	179.10	33.38(f)	15.48(e)	72.11
45	133.78	184.68	32.36(f)	15.48(e)	73.24
50	142.75	193.00	31.37(f)	14.25(e)	74.89
55	144.73	195.95	29.27(f)	14.25(e)	76.26
60	150.90	204.70	27.30(f)	13.37(e)	79.08
65	161.85	212.85	24.15(f)	11.38(e)	82.00
70	167.65	227.80	22.42(f)	8.20(e)	86.67
75	178.75	234.63	19.42(f)	4.25(e)	89.17
80	186.70	239.60	17.46(f)	2.45(e)	89.80
85	213.58	252.65	15.35(f)	1.55(e)	93.06
90	221.60	261.60	9.45(f)	7.60(f)	95.68
95	227.53	293.55	9.55(e)	13.55(f)	100.82
>95	270.50	387.50	14.50(e)	31.50(f)	108.40

A = angle, C = concentric, E = eccentric, P = peak, T = torque, NM = Newton meters ° = degree, e = extension, f = flexion

The percentile rankings for the assessed computer average trunk extensor muscular strength of three maximal voluntary contractions are displayed in Table 4.17. The median for -CT and -ET columns are 94.00 Nm and 133.75 Nm, respectively. The range for the -CT column is 21.50 Nm to 158.50 Nm. The range for the -ET column, at 67.50 Nm to 249.50 Nm, is larger than that of the -CT.

Table 4.17 Percentile Rankings for the Assessed Computer Average Trunk Extensor Muscular Strength of Three Maximal Voluntary Contractions (N=79)

Percentile	-CT (Nm)	-ET (Nm)
<5	21.50	67.50
5	53.45	77.45
10	56.85	87.40
15	62.35	92.35
20	73.76	100.90
25	76.25	106.25
30	79.73	116.73
35	85.15	120.15
40	89.80	124.10
45	91.78	130.05
50	94.00	133.75
55	96.70	137.95
60	100.70	147.63
65	101.59	148.68
70	107.80	153.65
75	115.75	157.63
80	124.70	164.70
85	136.65	173.58
90	144.60	182.60
95	148.55	194.55
>95	158.50	249.50

C = concentric, E = eccentric, T = torque, Nm = Newton meters, - = average

Table 4.18 displays the percentile rankings for the assessed and calculated trunk extensor muscular endurance variables. The percentile ranking column that summarizes the W20C demonstrates a median of 1700.50 J, with a range from 873.50 J to 3405.50 J. The W20E column displays a median of 1933.50 J, with a range from 653.50 J to 3488.50 J. The percentile rankings of the FIC and FIE are the last variables to be displayed in Table 4.9. The medians for the FIC and FIE are 0.915 and 0.715, respectively. The range of the FIC is from 0.545 to 1.665 and the range for the EPT is from 0.445 to 1.215.

Table 4.18 Percentile Rankings for the Assessed and Calculated Trunk Extensor Muscular Endurance Variables (N=79)

Percentile	W20C (J)	W20E (J)	FIC	FIE
<5	873.50	653.50	0.545	0.445
5	1253.10	1217.10	0.671	0.527
10	1311.70	1357.70	0.746	0.566
15	1350.30	1385.30	0.773	0.617
20	1382.90	1484.90	0.796	0.626
25	1519.50	1672.50	0.805	0.635
30	1554.10	1750.10	0.841	0.676
35	1596.70	1795.70	0.846	0.686
40	1627.30	1813.30	0.889	0.706
45	1653.90	1889.90	0.906	0.706
50	1700.50	1933.50	0.915	0.715
55	1775.10	1977.10	0.948	0.727
60	1839.70	2100.70	0.975	0.756
65	1907.30	2183.30	0.993	0.778
70	2090.90	2278.90	1.059	0.787
75	2228.00	2338.50	1.095	0.815
80	2391.10	2369.10	1.108	0.837
85	2485.70	2550.70	1.187	0.855
90	2576.30	2765.80	1.413	0.862
95	2911.90	3165.90	1.499	0.999
>95	3405.50	3488.50	1.665	1.215

C = concentric, E = eccentric, FI = fatigue index, J = joules, W = work

Histograms for Trunk Extensor Muscular Strength and Endurance Variables

Diagrams 4.1 to 4.11 are histograms that represent the percentile tables displayed in Tables 4.16 to 4.18. Each percentile increment contains a frequency of approximately 4 female RNs.

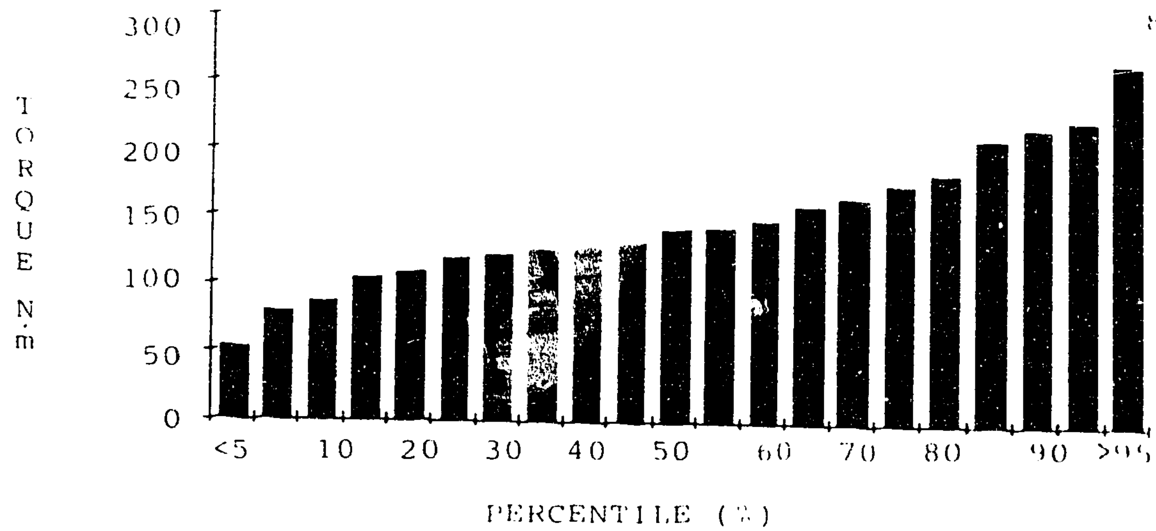


Diagram 4.1 Graphic Representation of the Percentile Rankings for Trunk Extensor Concentric Peak Torque (CPT) (N=79)

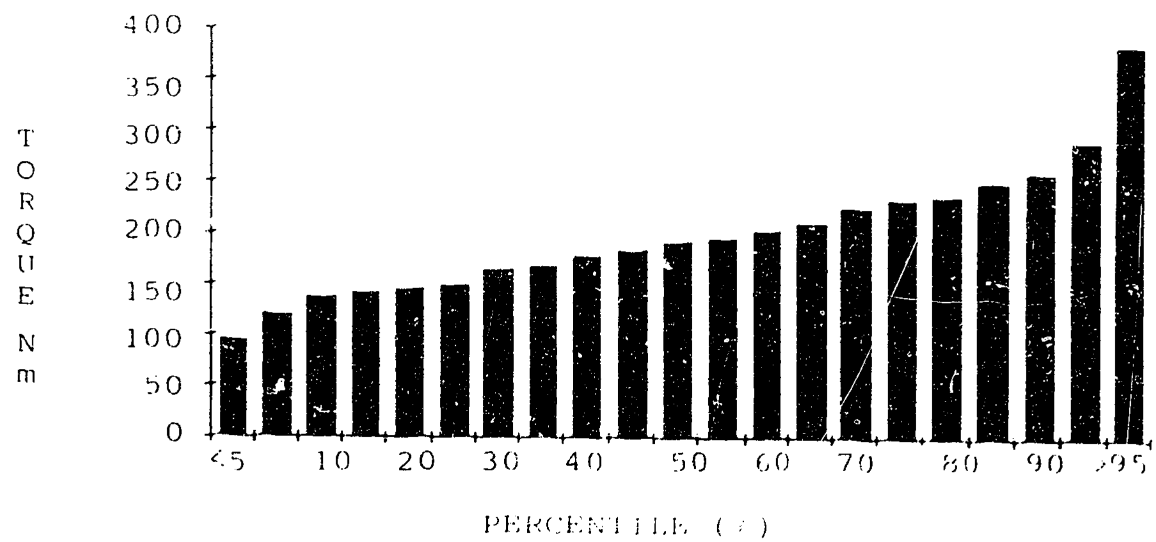


Diagram 4.2 Graphic Representation of the Percentile Rankings for Trunk Extensor Eccentric Peak Torque (EPT) (N=79)

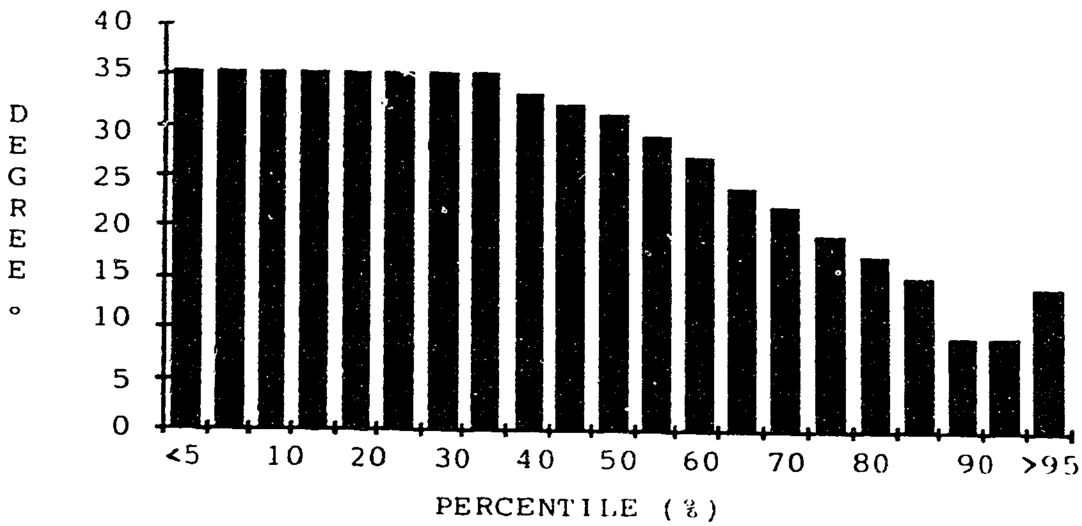


Diagram 4.3 Graphic Representation of the Percentile Rankings for Trunk Extensor Concentric Angle of Peak Torque (CAPT) (N=79)

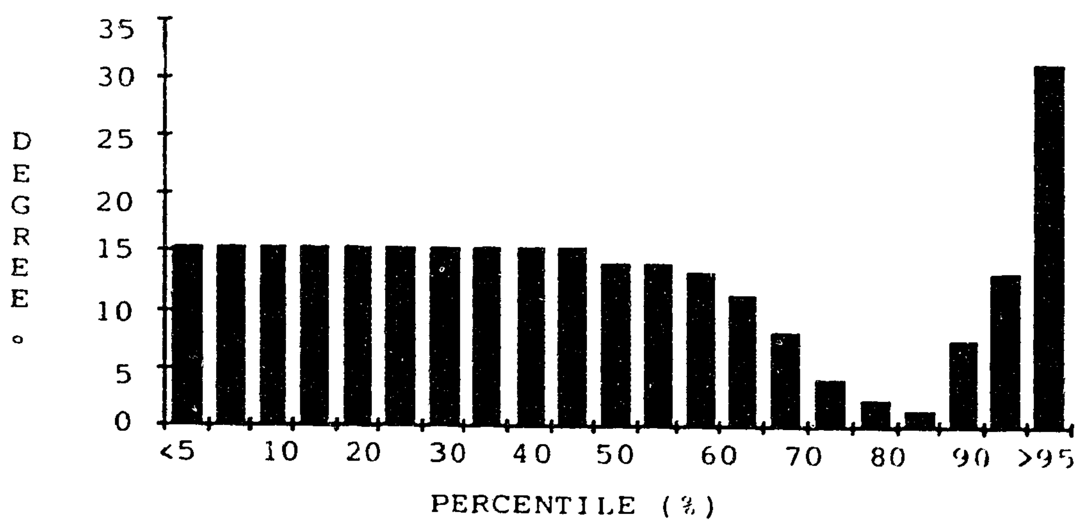


Diagram 4.4 Graphic Representation of the Percentile Rankings for Trunk Extensor Eccentric Angle of Peak Torque (EAPT) (N=79)

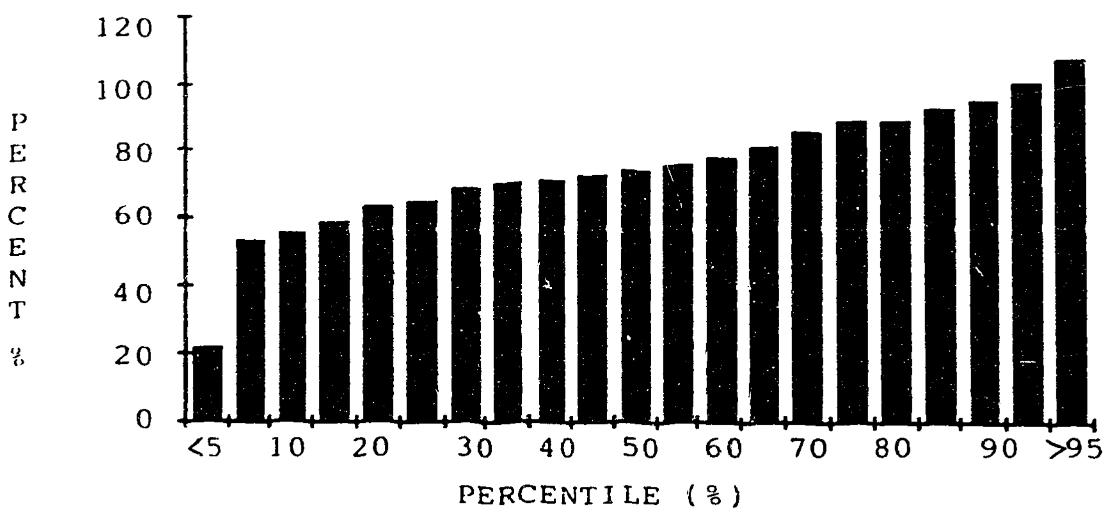


Diagram 4.5 Graphic Representation of the Percentile Rankings for the Relationship Between Trunk Extensor Concentric and Eccentric Peak Torques (% CPT/EPT) (N=79)

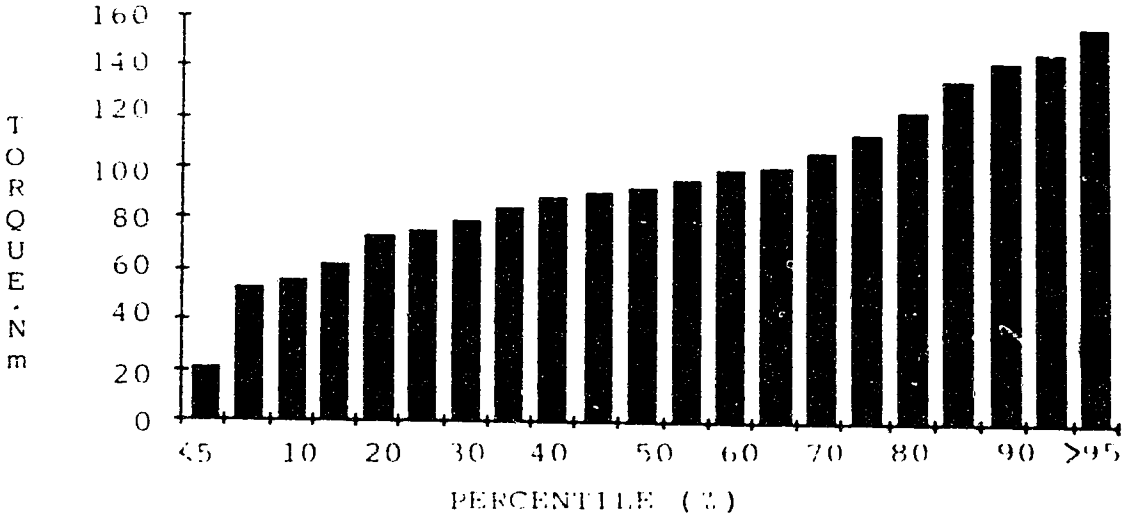


Diagram 4.6 Graphic Representation of the Percentile Rankings for the Assessed Computer Average Trunk Extensor Concentric Strength of Three Maximal Voluntary Contractions (-CT) (N=79)

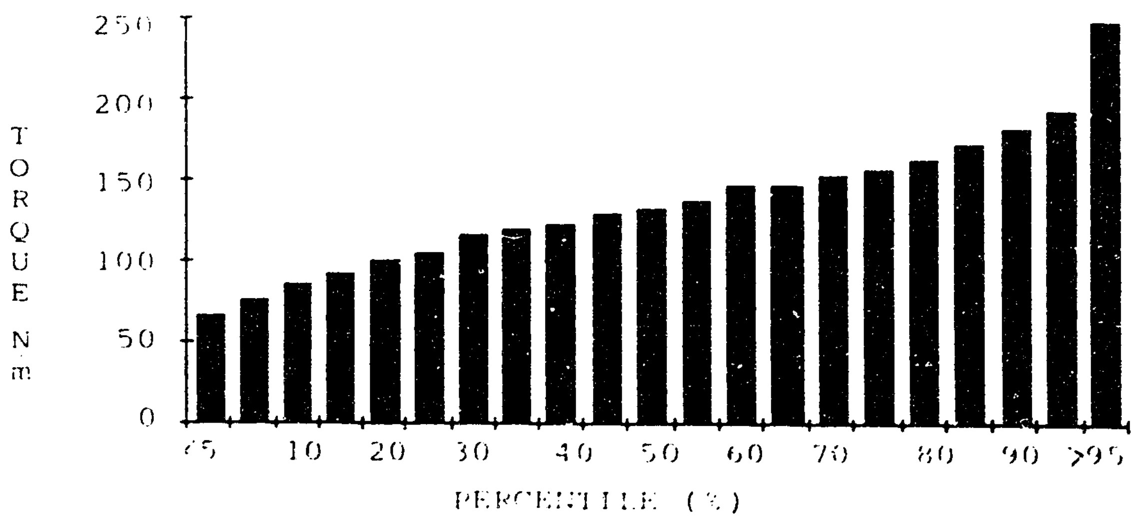


Diagram 4.7 Graphic Repres[illegible]tion of the Percentile Rank[illegible]s for the Assessed Computer Average Trunk Extensor Eccentric Strength of Three Maximal Voluntary [illegible] [illegible] (-E[illegible]) (N 79)

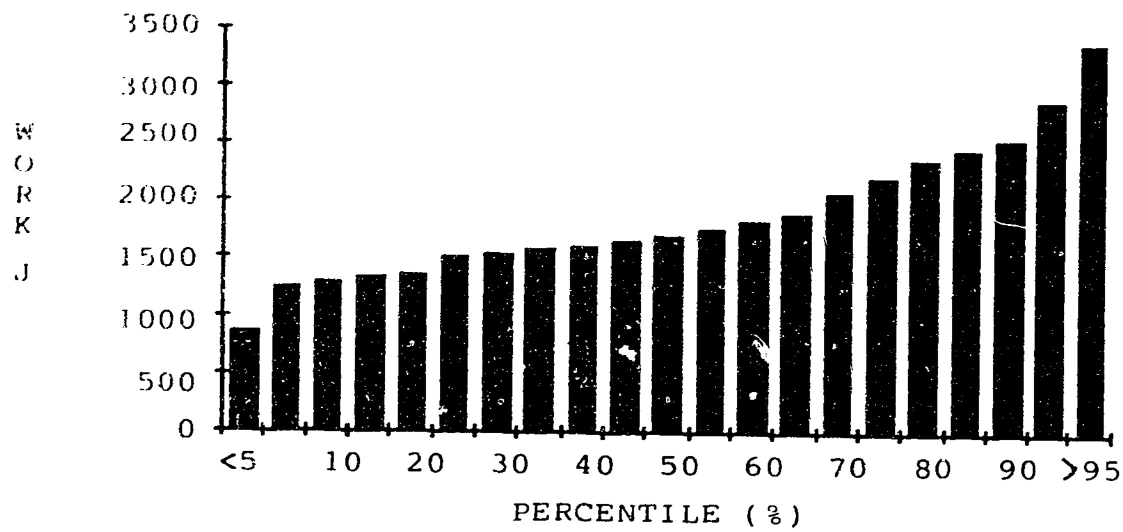


Diagram 4.8 Graphic representation of the Percentile Rankings of Trunk Extensor Concentric Work of Twenty Repetitions (W20C) (N=72)

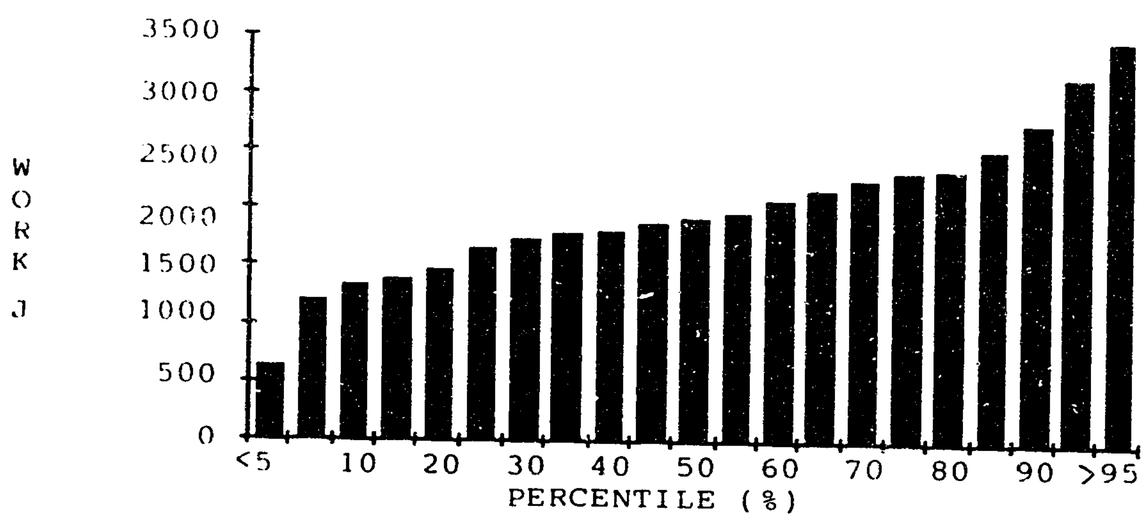


Diagram 4.9 Graphic Representation of the Percentile Rankings of Trunk Extensor Eccentric Work of Twenty Repetitions (W20E) (N=72)

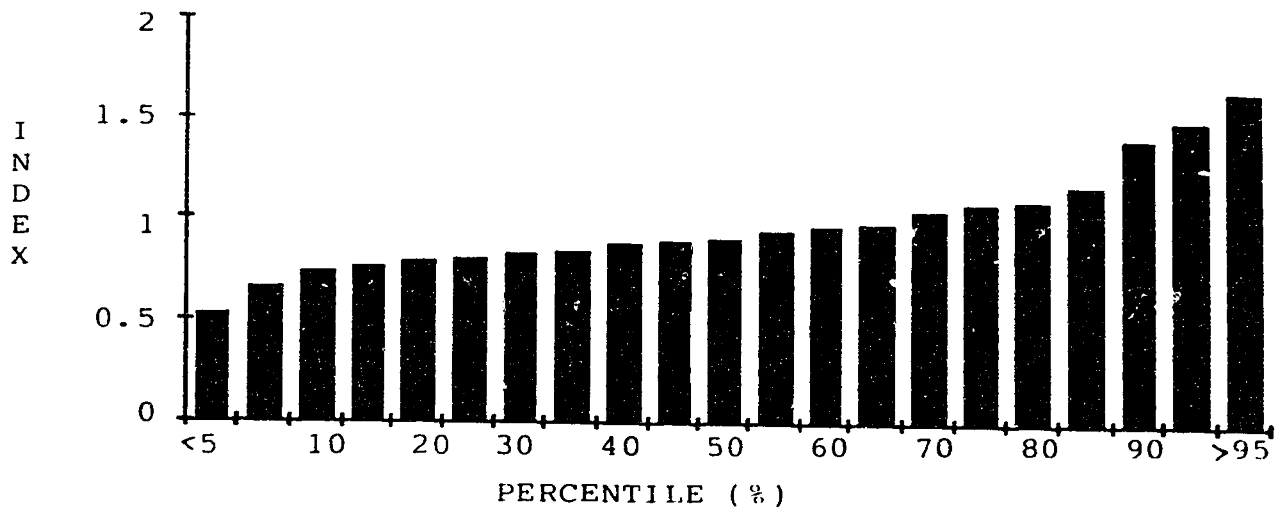


Diagram 4.10 Graphic Representation of the Percentile Rankings of the Trunk Extensor Concentric Muscular Fatigue Index (FIC) (N=72)

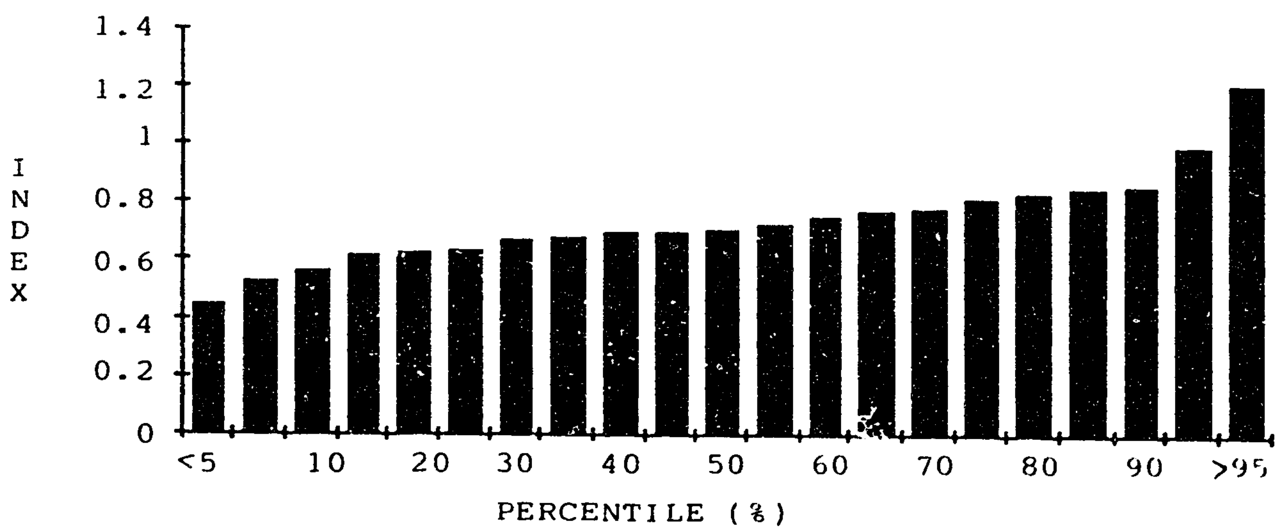


Diagram 4.11 Graphic Representation of the Percentile Rankings of the Trunk Extensor Eccentric Muscular Fatigue Index (FIE) (N=72)

CHAPTER V

DISCUSSION

Introduction

The following discussion will be presented under five headings; a) subject recruitment, b) reliability of the trunk extensor strength and endurance testing protocol, c) trunk extensor concentric and eccentric muscle strength variables, d) physical demands of nursing, and e) implications of trunk extensor eccentric normative data for female RNs.

Subject Recruitment

Approximately 87 percent of the subject group was recruited from the University of Alberta Hospitals (U of A Hs). Subject recruitment for this study, was extremely time consuming and tedious. Many hours were spent recruiting, but only a small percentage of the Edmonton RN population volunteered for the study. For example, over 2000 RNs are employed at the U of A H, but only 69 or 0.08% of the RNs volunteered (excluding approximately 10 RN's who did not pass the initial screening questionnaire and were therefore, excluded from participating in the study).

Approximately 32 percent of the subject group worked on physically demanding nursing units (eg. critical care and rehabilitation units), while the remaining 68 percent of the subject group came from a variety of nursing units (eg. medical and maternal). Since most nursing units were represented to some extent or another, in this study, the results of this study may be applicable to the general RN population.

Reliability of the Trunk Extensor Muscular Strength and Endurance Testing Protocol

The Kin-Com isokinetic dynamometer operations systems are both reliable and valid (Farrell, 1986). Reliability of the trunk extensor muscular strength and endurance testing protocol, of this study, was assured by using the test-retest method, utilizing a sample of eight, healthy, females. Significant Pearson product moment correlation coefficients ($p<.05$) were produced for trunk extensor concentric peak torque, computer averaged concentric and eccentric torque over three voluntary, maximal contractions and total concentric and eccentric work completed during the 90 second endurance test (refer to Table 4.11).

The strength protocol was not completely reliable, for the reliability group tested. One plausible explanation is the Kin-Com isokinetic trunk muscular testing was unfamiliar to the subject group and as a result, differences between the test-retest values existed. As indicated earlier, Wessel (1988) suggested the average torques may be a better measure of strength than identifying a peak torque. Results of the reliability portion of this study support Wessel's suggestion, in that the computer averaged concentric and eccentric torque over three maximal voluntary contractions were shown to be reliable measures. The trunk extensor concentric peak torque was identified as being a reliable measure, while the trunk extensor eccentric peak torque was not catalogued as a reliable measure. Since eccentric muscle testing is new and unfamiliar to most populations, and due to day to day subject biological variance which can account for up to 10% in scores, the result is realistic.

The endurance protocol was also not completely reliable, for this reliability group tested. Even though the W20C and W20E were considered reliable measures, the FIC and FIE were not. The FIC and FIE are calculated expressions or variables (based on the values of CPT/EPT and W20C/W20E). If one portion of the calculation is not reliable, then the fatigue indices will be affected. Indeed, this is what happened. The EPT was identified as not being a reliable measure and therefore, the FIE was also identified as being unreliable. The FIC, on the other hand, was identified as being unreliable, even though the CPT and W20C were both reliable measures. One plausible explanation is the reliability group consisted of only eight females. With such a small n, a correlation of almost perfect proportions, must exist, between the two variables (Day 1 FIC and Day 2 FIC) before it will be considered significant at the $p<.05$ level.

A larger reliability group could possibly render the FIC reliable, even though the endurance protocol and the calculations of the FIC would remain the same.

Although test-retest reliability was not performed using the RNs, a comparison was made between some of the six main variables between Trail 1 and Trial 2 of the strength testing protocol (refer to Table 4.12). All variables were significant at the $p<.05$ level. This indicated that a) the strength testing protocol was reliable for this subject group and b) sufficient time was allotted between strength trials to allow for maximal recovery.

Trunk Extensor Concentric and Eccentric Muscular Strength and Endurance Variables

Despite the difficulties in comparing data obtained from using different instruments, protocols, subject alignment and positioning methods (eg. axis of rotation alignment and resistance bar placement) and subject groups, general comparisons of trunk muscular strength and endurance data can be made.

In comparing the mean trunk extensor concentric peak torque (CPT) of this study with the results obtained in comparable research by Langrana (1984a), who assessed 26 healthy females, and Nordin (1987), who assessed 101 healthy females, the data was 18 to 34% higher. The CPT of this study was 149.5 (±47.2) Nm, whereas the CPT of the research conducted by Langrana and Nordin was 98.6 (±46) Nm and 122 (±40) Nm, respectively. One explanation for this discrepancy is that the subject group, in this study, with an average of 12.4 years of RN experience, may have developed increased trunk muscular strength over the years. This strength development could be an adaptation to the physical demands of nursing (ie. lifting and moving of patients). Different methodological procedures for data collection, such as subject alignment and positioning on the testing instrument, may also account for the difference in CPT.

Conversely, Smidt (1983) and Fenety (1989), produced CPT's that were 7 to 35% higher. Smidt (1983) isokinetically analyzed the trunk extensors of 12 females from a side lying position. The resulting CPT value was 160 Nm. A difference in body positioning and a smaller sample size may account for these differences in peak torque. Andersson (1988) suggested that if testing is performed in the standing position, greater hip extensor and flexor involvement may occur thereby increasing the CPT value. It may also be possible that trunk testing, while the subject is on her side, could lead to an increased hip involvement and a greater CPT value.

Fenety (1989) identified the CPT to be 201.25 (±12.80) Nm and 228.91 (±11.61) Nm in a group of female field hockey players and a group of healthy female university students. Both subject groups were considered extremely active. All of the subjects in Fenety's study were 18 to 28 years of age, which may account for the difference in the CPT values as compared to the current study. Thomas (1984) identified that age can account for torque differences (during isokinetic testing) in adult females regardless of speed of movement; an increase in age tends to cause a decrease in torque output. Although Thomas was referring to isokinetic testing of the knee flexor and extensor muscles, a comparable phenomena may exist when isokinetically analyzing the trunk muscles.

Trunk extensor eccentric peak torque (EPT), for this study, was 198.1 (±54.2) Nm. No comparable studies, identifying the EPT of females, could be found in the literature. Trunk extensor eccentric muscular strength testing is a relatively new phenomenon in research. With the advent of new testing instruments, such as the Kin-Com, eccentric muscle testing will become more prevalent. The daily physical demands of nursing require the RN to constantly lift and lower patients, therefore both concentric and eccentric trunk extensor muscular strength and endurance are important. By identifying both concentric and eccentric trunk muscular strength and endurance values, a complete profile of the back musculature can be developed.

Williams (1992) assessed the EPT of male university soccer players, football players, runners and non-athletes. The EPTs ranged from 326.6 (±21.5) Nm to 401.3 (±29.5) Nm.

Due to the difference in subject groups (female RNs vs. male university varsity athletes), substantial differences are identified when comparing the EPT's of the two studies. Under ideal conditions, women can usually generate strength values that are 55-75% of males (Davies, 1982; Hasue, 1980; Troup, 1969). Therefore, the female RN's EPT, which was 49 to 61% of the male varsity athletes' EPT, appeared to be a realistic value.

Smidt (1980) identified that trunk eccentric muscular contractions are stronger than both isometric and concentric muscular contractions, but isometric contractions are stronger than concentric contractions. The results of this study support Smidt's findings to the extent that the EPT was higher than the CPT. The relationship of CPT to EPT was assessed for descriptive purposes only and has no clinical significance. Comparisons between trunk flexion and extension are more commonly assessed (Nordin, 1987; Hasue, 1980). The CPTs of the subject group were approximately 76% of the EPTs. This result might be specific to nursing where RNs are continually lifting and lowering patients. Other occupations might produce a different relationship of CPT to EPT. Biemborn (1988), Langrana (1984), Davies (1982) and Hasue (1980) all agree trunk extension concentric force is greater than trunk flexion concentric force. Unfortunately, due to time constraints (on behalf of the subjects), trunk flexion concentric and eccentric muscular contractions were not assessed. The work:body weight ratios were also not computed in this study, unlike other studies (Williams, 1992; Fenety, 1989). However, the occupational demands of nursing are not dependent on body weight or height of the RN.

For analysis purposes, the data (of this study) was windowed to a range of motion of 50°. Five degrees were subtracted from both the starting angle and finishing angle, therefore, the actual range of trunk motion was 35° flexion to 15° extension. Windowing the data was necessary to compensate for inertial effects described by Baltzopoulos and Brodie (1989), who reported a 'torque overshoot' artifact at the beginning of the movement. The 'torque overshoot' phenomena is related to either the reaction of the dynamometer to the overspeeding limb (inertial effects) or a jerking motion of the limb. Muscular strength of the muscle group tested will be overestimated if the researcher chooses the 'torque overshoot' artifact to represent the subject's maximum force.

Nordin (1987) identified the average trunk extensor concentric angle of peak torque to be 32 (±17)° flexion for a group of 101 healthy females. A range of trunk motion was not predetermined, therefore the subjects worked within their own range of trunk motion limitations. Trunk extensor concentric angle of peak torque (CAPT), for the current study, was 25.5 (±12.4)° flexion (9.5° after the starting position of the test). A possible explanation for this minimal discrepancy is that the subjects in this study, were limited to a predetermined range of trunk motion of 60 degrees, which was further windowed to 50 degrees. It is interesting to note that 37% (29 RNs) of the subject groups' CAPT were influenced by the windowing procedure. This demonstrates that the subjects were unfamiliar with the Kin-Com and the movement pattern tested, resulting in a plethora of 'torque overshoot' artifacts (or inertial effects).

The trunk extension eccentric angle of peak torque (EAPT) was 8.7 (±9.9)° extension, occurring 6.3° after starting the test (similar to CAPT). The testing range of trunk motion was windowed from 15° extension to 35° flexion. Since research on trunk extensor eccentric strength is a relatively new phenomena, comparable studies are limited. Forty-eight percent of the subject group (38 RNs) were influenced by the windowing procedure, again indicating the movement pattern test on the Kin-Com was unfamiliar to the subjects. This point is emphasized since the standard deviation of EAPT and CAPT were relatively large (±9.9 and ±12.4, respectively). Minimal literature exists indicating where CAPT and EAPT ought to occur because the axis of rotation is not clearly defined for the trunk and is inconsistent between studies.

Wessel (1988) suggested the average torque over a series of maximal repetitions may be a more reliable measure of strength since learning the protocol and familiarization, with the testing instrument, play a key role in producing maximal forces. The computer average trunk extensor concentric and eccentric muscular strength of three maximal voluntary contractions (- CT and - ET), from this study, were 97.0 (±30.1) Nm and 134.8 (±36.1) Nm, respectively. Fenety (1989) identified higher average trunk concentric extension and trunk eccentric extension, over four maximal repetitions, as 143.3 (±6.3) Nm and 189.3 (±7.3) Nm for 12 field hockey players. The eleven healthy university females produced - CT and - ET as 115.6 (±8.0) Nm and 212.0 (±9.6) Nm, respectively. The results of Fenety's study are consistently higher due to the activity level and age of the sample groups.

Literature pertaining to identifying the trunk extensor concentric and eccentric endurance is virtually non-existent (especially utilizing a 90 second endurance test). Total work accomplished during the 90 second (20 repetitions) endurance test, was significantly different ($p<.01$) between the concentric (1865.8 J (±518.8)) and eccentric (2000.8 J (±603.7)) contractions but the wide range of results for both contraction types was similar. The concentric endurance contractions results produced a range from 873.9 J to 3488.5 J, a difference of 2532.3 J. The eccentric endurance contractions results produced a range from 654.0 J to 3406.2 J, a difference of 2434.5 J.

To reiterate, the trunk extensor muscular fatigue index for the concentric (FIC) and the eccentric (EIC) muscle contractions, refer to a calculated expression of the fatigability of the trunk extensor muscles during the 90 second endurance test. A calculated value over 1.0 represents minimal (or decreased) fatigability of the trunk extensor muscles, and therefore an increase in productivity (actual work per repetition). A value under 1.0 indicates maximal (or increased) fatigability of the trunk extensor muscles, and therefore a decrease in productivity (actual work per repetition).

The mean FIC was calculated to be .98 (±.25), which indicated the trunk extensor concentric muscle contractions were causing the trunk extensor muscles to be fatigued (productivity was decreasing) by the end of the 90 second test, but not to an exhausted level. The lowest recorded FIC was .55 which indicated maximal exhaustive fatigue. Seven RNs were unable to finish the endurance test, two of which were attributed to physical exhaustion. The highest recorded FIC was 1.67, which indicated minimal fatigue (increased productivity), even though the majority of the RNs indicated, upon completion of the endurance test, that the test was difficult and physically exhausting. Therefore, physical exhaustion was perceived to be greater than that actually reported.

The mean FIE was calculated to be .74 (±.14) with a range of .45–1.22, indicating that the trunk extensor eccentric muscle contractions were causing the trunk extensor muscles to be fatigued by the end of the 90 second test, but to more of an extent than the trunk extensor concentric muscular endurance contractions. The highest recorded value of 1.22 marked minimal fatigue (or increased productivity), but not to the extent of the FIC. Therefore, the overall trunk extensor eccentric muscular endurance might be less than the trunk extensor concentric muscular endurance. Such wide ranges of values for the FIC and FIE might be indicative of the distribution of muscle fibers incorporated in the trunk extensors of the subject group or specific adaptations as a result of daily nursing tasks. Smidt (1980) and Astrand (1977) identified that trunk flexors fatigue faster than trunk extensors due to the dominance of the slow twitch oxidative (Type I) muscle fibers. Thortensson (1987) supports this assumption: Thortensson identified a large interindividual variation of Type I and Type II (fast twitch glycolitic muscle fibers) fibers in the multifudus and longissimus muscles through muscle biopsy. The mean fiber distribution between the two muscles were Type I 62% vs. 57%, Type IIa 20% vs. 22% and Type IIb 18% vs. 22%, respectively. Another plausible explanation for the wide ranges demonstrated in the fatigue indices might be the ability of some of the RNs to recruit the hip flexors and extensors (despite subject stabilization), thus retarding the fatiguing of the muscle fibers. The relationship between trunk extensor concentric and eccentric muscular strength and endurance warrants further investigation.

Physical Demands of Nursing

The work of a RN is physically demanding, and often exceeds the Action Limits (AL) and the Maximum Permissible Limits (MPL) for lifting, imposed by existing legislations (Pheasant, 1987; Stubbs, 1983). The United States Dictionary of Occupational Titles (from the Department of Labour) (1981) identified the physical demands of a general duty nurse to be at a medium work level (lifting 50 lbs. maximum with frequent lifting and/or carrying of objects weighing up to 25 lbs.). The Canadian Classification and Dictionary of Occupations (CCDO) (from Employment and Immigration Canada, 1980) identified similar physical demands, with the exception of frequent lifting and/or carrying of objects weighing up to 20 lbs. Careers Alberta (1981) describe the physical demands of nursing as light to medium. The University of Alberta Hospitals RN generic job description (1992) describes the need for a physical and mental health status sufficient to assure capability in the performance of routine and emergency nursing duties. It is obvious that the occupational demands of nursing far exceed the documented physical demands, especially on those nursing units that require much more physical manipulation of patients (U.S. Department of Labour, 1981; CCDO, 1980). Potential RNs are unaware of the "real" physical demands of nursing and furthermore, the term "medium" work load is ambiguous and not realistically defined. Lifting (usually of patients) is a primary task of nursing. Since this task is often completed in unusual body postures and proper body mechanics can not be utilized (Harber, 1985), leg and trunk muscular strength and endurance are essential. Therefore, trunk muscular strength and endurance normative data would be useful in a variety of ways. Based on the results of this study, health care practitioners need to review the CCDO. The results of this study could supplement the CCDO, which in turn would make the CCDO a more valid tool with regards to defining the physical demands of nursing.

Implications of Normative Data

A compilation of trunk muscle performance data (ie. normative isokinetic dynamometry data) could benefit and enhance the development of pre-employment screening, aid practitioners in the rehabilitative process following injury and aid in establishing safe work loads for RNs.

Pre-employment screening can be a sensitive issue, but the occurrence of occupational low back pain in nursing is prevalent. If potential RN employees lack trunk muscular strength and endurance, preliminary steps can be taken (via administration of a trunk strengthening program) to strengthen these muscles and therefore decrease the chances of experiencing occupational low back pain (OLBP). A normative database of female RN trunk extensor muscular strength and endurance (such as the one developed in the present study) is essential and can be used a) to identify trunk muscular strength and endurance, and b) as a standard, for potential RNs who lack trunk muscular strength and endurance, to work toward. A preventive approach to the problem of OLBP should be taken, as opposed to providing a solution after the problem has occurred (eg. days off work after the OLBP has already been experienced).

Rehabilitating injured workers is a common practice in our society, but occupational rehabilitative standards (eg. female RN normative isokinetic dynamometry data) are non-existent, especially concerning the trunk muscles. Appropriate trunk muscle rehabilitating standards would facilitate health care practitioners (eg. physical and occupational therapists) in returning an injured worker to the work force. Isokinetic dynamometer norms, of trunk extension, for female registered nurses developed in the present study can serve as an initial occupational rehabilitative standard for the back. The quicker an injured worker can return fully functional to the job, the more cost effective it is for our society, providing that the injured worker is physically ready to return to employment.

Establishing safe work loads, for different occupations, is a difficult task. By establishing female RN trunk extensor muscular strength and endurance normative data (eg. the results of this study), trunk muscular strength and endurance limitations, for RNs are identified. This information is essential when attempting to develop safe work loads: the ultimate goal being to avoid injuring the back's of RNs.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary and Conclusions

The purpose of this study was to develop isokinetic dynamometer norms of trunk extensor eccentric muscular strength and endurance for female registered nurses. Seventy-nine female RNs (19 to 58 years of age) from hospitals in the Edmonton area, participated in the study. Reliability of the trunk extensor eccentric muscular strength and endurance testing protocols were also conducted.

Each female RN was required to attend one testing session, lasting approximately 35 minutes. The physiological testing sequence consisted of two sets of three maximal voluntary concentric/eccentric coupled trunk extensions, followed by a 90 second (20 repetition) concentric/eccentric coupled trunk extension endurance test. All tests were performed on a Kin-Com isokinetic dynamometer at a speed of 30° per second, through a 60° range of trunk motion.

The muscular strength and endurance results were compiled into percentile ranking tables, where the median represented the 50th percentile. The mean trunk extensor concentric and eccentric peak torques were 149.5 (±47.2) Nm and 198.1 (±54.2) Nm, respectively. The average trunk extensor concentric angle of peak torque was 25.5 (±12.4)°

flexion, whereas the eccentric angle of peak torque was 8.7 (±9.9)° extension. The computer average (over three maximal, voluntary contractions) trunk extensor concentric and eccentric torques were 97.0 (±30.1) Nm and 134.8 (±36.1) Nm, respectively. The total work completed, during the 90 second trunk extensor muscular endurance test was 1865.8 (±518.8) J for the concentric contractions and 2000.8 (±603.7) J for the eccentric contractions. The muscular fatigue index of the concentric trunk extensor endurance was .98 (±.25) whereas the muscular fatigue index of the eccentric trunk extensor endurance was .74 (±.14). Both types of muscular contractions caused the trunk extensor muscles to fatigue, but the eccentric muscle contractions caused the trunk extensor muscles to fatigue to a greater extent.

Test-retest Pearson product moment correlation coefficients were determined for the testing protocol variables, using a healthy female subject reliability group. Concentric peak torque, computer averaged concentric torque, computer averaged eccentric torque, total work of 20 concentric muscle contractions and total work of 20 eccentric muscle contractions were significant at $p<.05$. Eccentric peak torque, concentric angle of peak torque, eccentric angle of peak torque, the relationship between concentric peak torque and eccentric peak torque, fatigue index for the concentric contractions and fatigue index for the eccentric contractions were not significant at $p<.05$.

Pearson product moment correlation coefficient comparisons were conducted between Trial 1 and Trial 2 of the RN's strength testing protocol. All of the strength variables were significant at $p<.05$.

Recommendations

The following recommendations are presented for further study related to trunk strength and endurance testing;

1. Assessment of trunk flexion strength and endurance of female registered nurses, in order to develop a complete understanding and normative data base of the trunk muscular strength and endurance of female RNs.
2. Assessment of trunk muscular strength and endurance in the standing position in order to quantify the contribution of the hip flexors and extensor to trunk extension.
3. Standardization of the instruments and protocols used for the assessment of trunk muscular strength and endurance in order to develop a comparison between study results.
4. Assessment of trunk extensor muscular strength and endurance of other occupational groups (eg.physiotherapists).

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APPENDIX A

RECRUITMENT ADVERTISEMENTS

ATTENTION

FEMALE REGISTERED NURSES NEEDED.... NOW!

Occupational low back pain is a major source of suffering, incapacitation and cost to the world today. The nursing profession is one of the largest occupations where incidence of compensable back injuries is prevalent. Unfortunately, current literature only identifies the problem. Research is needed to reduce the problem.

One hundred (100) to one hundred and fifty (150) female registered nurses are needed for a research project which identifies back muscular strength and endurance. Volunteers who **have not** experienced low back pain in the last twelve (12) months are required. By identifying back muscular strength and endurance, steps can be taken towards reducing the number of compensable back injuries in nursing.

Non-invasive back muscular strength and endurance testing will take place in room 1-79 at Corbett Hall (right beside the University of Alberta Hospitals) on 114 street between 83 and 84 avenue. Testing will be conducted from May 19 to June 30. A Kin-Com dynamometer will be used as the testing instrument. **Thirty minutes** of your time is all that is required!

PLEASE volunteer for this research project. Call a) **Dr. Dan Syrotuik** at **492-1018** or b) **Erin Payette** at **438-1398** (H) or **492 -7336** (W) to set up a time that is convenient for you. If Dr. Syrotuik or Erin Payette are not available when you call, please leave a message (including your name and phone number) and your call will be returned as soon as possible.

Please help us to reduce the problem of low back pain in nursing. This is the first step in a positive direction!

"HELP US TO HELP YOU"

Nurses Needed

- Low Back Pain In Nursing -

A Well Known Problem, But You Can Help

Become a volunteer for a research project which identifies back muscular strength and endurance. Thirty minutes of your time is all that is required.

For More Information, Please Contact
Dr. Dan Syrotuik at 492 - 1018.

"Help Us To Help You"

APPENDIX B

RESEARCH PROJECT AND INFORMED CONSENT

FOR

PHYSIOLOGICAL ASSESSMENTS

RESEARCH PROJECT AND INFORMED CONSENT
FOR PHYSIOLOGICAL ASSESSMENTS

DEPARTMENT OF PHYSICAL EDUCATION AND SPORT STUDIES
UNIVERSITY OF ALBERTA

PRELIMINARY ISOKINETIC DYNAMOMETER NORMS OF TRUNK MUSCLE EXTENSION

FOR REGISTERED NURSES

Investigator: Erin K. Payette (436 - 4596 H; 492 - 5503 W): MSc Candidate
Supervisor: Dr. D.G. Syrotuik (492 - 1018 W)

<u>PURPOSE OF THE STUDY:</u> To investigate the trunk muscle performance of female registered nurses and to develop preliminary normative isokinetic dynamometry data.

<u>TESTING PROCEDURES:</u> Prior to the testing, an orientation of the testing equipment, procedure, and nature of the study will be conducted. Each subject will complete a modified Physical Activity Readiness Questionnaire (PAR-Q). Any registered nurse who has experienced low back pain within the last twelve months will not be allowed to participate in the study. All subjects are asked to 1) refrain from vigorous activities 24 hours prior to the testing and 2) avoid smoking, intake of caffeine and eating 2 hours prior to testing. Prior to the actual data collection, each subject will complete a predetermined warm-up stretch.

During trunk muscle strength testing, subjects will be positioned on the Kin-Com Dynamometer in a seated position, with the hips and legs stabilized via additional attachments. To begin the testing sequence, the subjects will be positioned in 40° flexion. Each subject will be asked to push up on the pressure pad until 20° of trunk extension is reached. After a momentary pause, each subject will be asked to resist the movement of the pressure pad as it attempts to push the subject back to the starting position. Each subject will be instructed to a) maintain a normal breathing pattern, b) focus the eyes on an object in front of them and stick the chin out as they move through each contraction, c) hold the hands together in front of the trunk and d) continue exercising until a voice from the computer instructs the subject to stop exercising. The first set of three trunk concentric/eccentric contractions will be performed at a submaximal voluntary level for familiarization and warm-up purposes. The next two sets of trunk contractions will be performed at a maximal voluntary level. After each set of three contractions, a two minute rest will be allowed.

During trunk muscle endurance testing, the subject will be positioned in the same manner as the strength testing. The instructions are the same with the exception that: a) the subject will be asked to continually perform concentric/eccentric extensions for approximately 90 seconds at a voluntary maximal level, and b) only one trial will be performed. Verbal encouragement for maximal performance, on each test, will be given to each subject by the tester.

The testing session will be concluded with a brief predetermined cool-down stretch.

TIME COMMITMENT: Each subject is asked to commit approximately 30-35 minutes for testing purposes.

RISKS: Muscle soreness may be experienced by the subjects of this research study. Secondary trunk muscle soreness may be experienced immediately or up to 48 hours after the testing session (with peak secondary muscle soreness occurring 24 hours after the testing session). If a proper warm-up is performed, chances of injury are decreased. Numerous studies, using isokinetic dynamometry, identify minimal risk to the subject during analysis of trunk muscle performance

INFORMED CONSENT FOR SUBJECTS:

I have read the above and agree to participate in this research project at my own risk. I realize that I may expect a thorough explanation and/or demonstration of any procedures now or at any time in the future, and that I may terminate participation at any time in any or all procedures of my own volition. I will also be assured anonymity of all results gathered in this research.

Name:...

Date:...

Address:..

....

Phone:..................................

Signature:..

Signature of witness......................................

Signature of investigator.................................

N.B. For further inquires concerning understanding of the procedures, please do not hesitate to call me at 436 - 4596(H) or 492 - 5503(W). If I am not available at the time you call, please leave a message on the answering machine and I will get back to you A.S.A.P.

APPENDIX C

MODIFIED PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

PAR-Q and YOU

ANSWER		QUESTION
YES____ NO____	1)	Has your doctor ever said you have heart trouble?
YES____ NO____	2)	Do you frequently have pains in your heart and chest?
YES____ NO____	3)	Do you often feel faint or have spells of severe dizziness?
YES____ NO____	4)	Has your doctor ever said your blood pressure was too high?
YES____ NO____	5)	Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?
YES____ NO____	6)	Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?
YES____ NO____	7)	Are you over the age of 65 and not accustomed to vigorous exercise?
YES____ NO____	8)	Are you pregnant?
YES____ NO____	9)	Have you experienced low back pain in the last twelve (12) months?
YES____ NO____	10)	Have you ever consulted a physician for low back pain in the last twelve (12) months?
YES____ NO____	11)	Have you ever experienced a disc or neural problem of the lower back?
YES____ NO____	12)	Have you ever required surgery to repair a vertebra?

Name of participant..

Signature..

Date..

: Reference: PAR-Q Validation Report. British Columbia Ministry of Health, 1978

APPENDIX D

RESEARCH PHOTOGRAPH RELEASE FORM

RESEARCH PHOTOGRAPH RELEASE FORM

I, ______________________________ agree to be photographed in the trunk testing unit for the study, "preliminary Isokinetic Dynamometer Norms of Trunk Muscle Extension for Female Registered Nurses" conducted by Erin Payette, a Masters student, supervised by Dr. Daniel Syrotuik, Director of Research and Sport Services, Department of Athletics. I understand that the photographs will be used for teaching and research purposes only. If the photographs are used in a publication or public presentation, I will not be identified by name, but visually I will be identified.

I have received a copy of this release form for my own purposes.

____
Subject's signature

____
Witness

____
Date

APPENDIX E

DATA COLLECTION SHEET

Disc#____

Data Collection Sheet

1. CODE ______________ NAME ____

2. EMPLOYER ____

3. NO. OF YEARS PRACTISING AS A R.N. ____________________________

4. UNIT______________________________FULL TIME_____PART TIME_____

5. DEMOGRAPHIC DATA:

   : age __________________ yrs.
   : wt. __________________ kgs.: ________________ lbs.
   : ht. __________________ cms.: ________________ ins.

6. RADIUS ARM SETTING ____

   GRAVITY COMPENSATION ______________________________________
   Gravity angle ______
   Reference angle ______

7. STRENGTH TESTING RESULTS:

   : set #1
   CPT _____________(Nm) CAPT _______________(°)
   EPT _____________(Nm) EAPT _______________(°)
   -CT _____________(Nm)
   -ET _____________ (Nm)

   : set #2
   CPT _____________(Nm) CAPT _______________(°)
   EPT _____________(Nm) EAPT _______________(°)
   -CT _____________(Nm)
   -ET _____________ (Nm)

8. ENDURANCE TESTING RESULTS:

   W3C set #1 ________/set #2 ________

   W3C set #1 ________/set #2 ________

9. TOTAL WORK CON. _______________________ : for 20 reps
   TOTAL WORK ECC. _______________________ : for 20 reps

10. ADDITIONAL INFORMATION