CHAPTER 3: METHODS AND PROCEDURES:

3.1. Gathering of information:

The first step was to do a proper literature search in order to gather as much relevant information as possible. A number of databases were screened for relevant information, such as “EBSCO HOST”, “Science Direct”, “Medline”, “PsycLIT”, “DIALOG”, and “SPORT Discus”. Databases on the “World Wide Web” that were used, included “MetaCrawler.com”, “Altivista.com”, “Biomednet.com”, and “BJM.com”. Information was also gathered in the library of the University of Pretoria itself and through interaction with other experts on work-related physical assessments in South Africa.

3.2. The target population:

The target population for this study was the blue-collar workers (physical workers) within a specific department of a South African electricity supply companies` northern region.

3.3. Job analysis:

A proper job analysis is one of the most critical steps in designing a test battery for work-related physical ability testing. Shrey and Lacerte (1997) states that the test administrator must have a clear and precise understanding of the physical demands for each of the tasks that are crucial to the successful performance of the job. Once the crucial demands are identified, the test battery should be designed to assess the individual`s ability to perform the work tasks.

There are many ways of gathering job analysis information. The section on “job analysis”, in chapter 2, takes a look at a few of the popular approaches that can be used. The technique one uses depends to a great extent on the specific purpose. It is usually useful to employ as many information sources as possible to develop information about jobs (Fleishman, 1979; Toeppen-Sprigg, 2000).

The methods used during the job analysis process in this study consisted of the analysis of the official job descriptions/profiles of the relevant jobs, interviews with relevant supervisors and employees, as well as a video analysis of all the physical tasks to be performed by the relevant physical workers on a daily basis.

3.3.1. Analysis of job descriptions/profiles:

This study focussed on one department of SA ELEC. Within this department, there are a number of different jobs. A job description/profile for each one of these jobs was provided by the company and thoroughly studied in order to, firstly, identify those jobs that qualify as physical jobs with inherent physical requirements and, secondly, to assist in the identification of critical physical outputs and critical physical tasks within these identified jobs. Table 3.1 shows an example of one of these job profiles.

Four jobs within the relevant department were identified as "physical jobs" with "inherent physical requirements" and a number of outputs that could require an employee to perform physically demanding tasks were identified. Here follows a list of the outputs that were identified:

- operating vegetation control machines;
- clearing vegetation by manual labour;
- installing and restoring fences and gates;
- restoring, maintaining roads and drainage systems;
- replacing, securing and cleaning line components and electrical connections;
- conductor stringing, binding and jointing;
- excavating, back filling and compacting to secure structures and trenches;
- executing foot and vehicle patrols to identify and report faulty plant;
- replacing, repairing, securing and cleaning plant and equipment in substations;
- restoring equipment and structures on lines and substations;
- dressing, erecting and installing poles and structures;
- dismantling poles and structures;
- installing and dismantling reticulation and urban transformers, reclosers, sectionalisers, metering points, isolators and drop out fuse links;
- executing site restoration in accordance with environmental control measures; and
- executing safe handling and economic stacking and storing of material.

Table 3.1: Example of an SA ELEC Job Profile/Description:

SA ELEC	JOB PROFILE / DESCRIPTION	

JOB MISSION / PURPOSE

To ensure the continuity of supply to customers by building, maintaining, and repairing infrastructure and plant in accordance with Policies, Directives, Standards, Procedures, Work practices, Guidelines and Service agreements.

1. MAINTENANCE: PERFORMS PLANNED MAINTENANCE ON NETWORKS AND INFRASTRUCTURE IN ACCORDANCE WITH THE STANDARDS, PROCEDURES, DIRECTIVES, WORK PRACTICES AND GUIDELINES.

1.1. Perform Vegetation Control (In Eskom' s Servitude's) by:

- Operating vegetation control machines.
- Clearing vegetation encroaching on clearance distances and structures by manual labour. (Environmental care)
- Applying prescribed growth control chemicals.

1.2. Maintain Access Routes and Security infrastructure by:

- Installing, inspecting and restoring fences and gates.
- Restoring, maintaining and reporting conditions of roads and drainage systems.

1.3. Maintain lines and structures by:

- Replacing, securing and cleaning line components, electrical connections and anti-oxidation measures (e.g. Insulators, cross arms, bolts and nuts, electrical connections, anti climbing devices, labels and identification markers).
- Conductor stringing, binding in and jointing including earthing.
- Excavating, back filling and compacting to secure structures and trenches.
- Executing foot and vehicle patrols to identify and report faulty plant.

1.4. Maintain Substations and control rooms by:

- Replacing, repairing, securing and cleaning plant and equipment in substations under guidance and supervision
- Inspecting, topping up with electrolyte, cleaning and testing the Specific Gravity of batteries
- Inspecting and reporting performance of security and safety lighting.
- Inspecting and reporting on condition of substation tools and equipment.
- Reporting any other abnormality found in/ on the network to appropriate person (e.g. Flags and status changes, oil leaks etc.)
- Executing vegetation control

1.5. Work order feedback and clearance

2. REPAIR : RESPOND TO CALL OUTS AND PROMPTS FROM THE DISPATCHER DURING ABNORMAL CONDITIONS AND POWER SUPPLY INTERRUPTIONS ON A 24 HOUR BASIS TO MINIMISE CUSTOMER OUTAGE By :

- Being on standby
- Restoring equipment and structures on lines and substations by replacing, securing and cleaning plant and equipment under supervision.
- Executing foot and vehicle patrols to identify and report faulty plant.
- Switching on Low Volt networks

3. BUILD: CREATES ASSETS ON URBAN AND RURAL LINES BY:

- Dressing, erecting and installing poles and structures
- Dismantling poles and structures
- Installing/ dismantling reticulation and urban transformers, reclosers, sectionalisers, metering points, isolators and drop out fuse links.
- Conductor stringing, binding in and jointing (Including earthing)
- Excavating, back filling and compacting to secure trenches and structures

4. HEALTH AND SAFETY: ENSURE A SAFE WORKING ENVIRONMENT AND ELIMINATE UNSAFE ACTS BY:

- Reporting all safety incidents, unsafe conditions and abnormal conditions to immediate supervisor.
- Inspecting and reporting non-conformance of tools and equipment immediately before use.
- Using and caring for personal protective equipment as per requirement.
- Effecting statutory and non-statutory appointment

5. CUSTOMER SERVICE: PROVIDE A ONE STOP CUSTOMER SERVICE BY:

- Reading and sealing cyclic and demand meters on small power users.
- Conforming to the Customer Service Charter.
- Giving milestone feedback.

6. HOUSE KEEPING: MAINTAIN AN ERGONOMICALLY SOUND AND HYGIENIC WORK PLACE BY:

- Cleaning of work sites, work stations and infrastructure.
- Executing site restoration in accordance with environmental control measures.
- Executing safe handling and economic stacking and storing of material.
- Assisting with site preparation under supervision by:

Erecting barricades and danger notification &
Preparing system earthing

Studying the job profiles/descriptions of the physical jobs, provided a good general idea of what the physical outputs were, which physical tasks could be involved, which of them could be the most physically challenging, and which of them could eventually be considered "critical". The next step was to talk to the people who perform these tasks on a daily basis.

3.3.2. Interviews:

Interviews were conducted with 6 individuals (2 senior technical officials, 2 technical officials and 2 assistant technical officials) and a separate group consisting of 5 assistant technical officials. The interviews consisted of two parts: (1) identifying the 10 most strenuous tasks, based on the analysis of the job profiles/descriptions and the subjective opinions of the employees being interviewed; and (2) subjectively rating each identified task by means of a 10-point scale (based on the RPE scale), with "0" being "very, very easy" and "10" being "very, very difficult". After the interviews were conducted, the ten tasks with the highest average rating were selected for the purpose of this study. See table 3.2 for an example of the questionnaire that was used.

Table 3.2: Example of a Strenuous Task Identification Questionnaire:

Strenuous Task Identification (0 = very,very easy) (10 = very,very difficult)											
Task	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
e.g. "Krimper"								X			

The interviewed employees identified the following ten tasks as the most strenuous (all ten of these tasks are used in performing the physical outputs mentioned earlier):

- vegetation control (working with a chainsaw, handsaw, etc.);
- working with a "stamper" (tool that`s used to compress sand, rock, and gravel);
- digging holes in the ground with a pickaxe and spade;
- lifting heavy objects from the ground, such as toolboxes, earthbags and branches;
- working with a "riccor" (tool that tightens cable);
- working with a "krimper" (tool that compresses cable);
- lifting a ladder or wooden pole above the head;
- replacing line components (e.g. transformers and conductors);
- stringing (manually pulling cables to cover long distances); and
- foot patrols (walking long distances).

3.3.3. Practical experience/observations and video recordings:

24 hours (two mornings and two full working days) were spent with teams of physical workers in the field. During this time, observations and video recordings of all the identified critical physical tasks were made as they were performed by the physical workers, and critical information was written down where applicable. Tools and equipment were also measured for weight, thickness, length, etc.

3.3.4. Video analysis:

Once the critical tasks were captured on videotape as they were being performed in the field, the analysis of the tasks could begin. Each task was thoroughly investigated for movements, body angles, exertions, etc. A qualified ergonomist with experience in working with physical workers assisted in the analysis. The objective was to identify the critical movements involved in performing each task, as the ultimate objective would be to assess each of these critical tasks in a test battery.

The critical movements and exertions that were identified through the analysis of the ten critical tasks, can be described as follows:

- lifting heavy objects from the floor to mid-thigh height (one handed), using mainly legs, upper body and arms - toolboxes, earthbags, branches, and chainsaws;

- maximum adduction of the arms (pushing two handles together) - "krimper", "riccor", and bolt cutter;
- lifting heavy objects above the head (two handed), using mainly arms and shoulders - ladders, wooden poles, and pickaxes;
- arm flexion- and general shoulder strength - "stamper", lifting heavy equipment and tools from a "bakkie";
- back extension strength - pickaxe, spade, chainsaw, and stringing;
- leg strength - stringing, lifting heavy objects from the ground, and climbing ladder;
- shoulder endurance - working with smaller tools on (or above) eye level for extended periods when replacing transformers, conductors, and other devices;
- cardiovascular endurance - foot patrols; and
- grip strength - all manual tasks.

These nine basic movements and exertions are present in the critical tasks mentioned earlier. In other words, these movements and exertions were chosen as the critical physical components that an employee must be able to perform to a certain extent in order to perform the job satisfactorily. Five of the nine movements/exertions identified were already being tested in SA-ELEC as part of the "factor tests" (see chapter 1) and would not be tested as part of this study. They were "arm flexion- and general shoulder strength", "back extension strength", "leg strength", "grip strength" and "cardiovascular endurance". The four remaining movements/exertions were used for the purpose of this study (see chapter 1). They can shortly be listed as:

(1) arm strength above the head (two handed) – Photo 3.1 show one activity where arm strength above the head is required (posed photo);
(2) maximum adduction of the arms (two handed) – Photo 3.2 show one activity where arm adduction is required (posed photo);
(3) lifting strength from the floor (one handed) – Photo 3.3 show one activity where lifting strength from the floor is required (posed photo); and
(4) shoulder endurance at eye level (one handed or two handed) – Photo 3.4 show one activity where shoulder endurance at eye level is required (posed photo).

Photo 3.1: Lifting a heavy ladder above the head:

Photo 3.2: Working with a bolt cutter:

Photo 3.3: Lifting and carrying a toolbox:

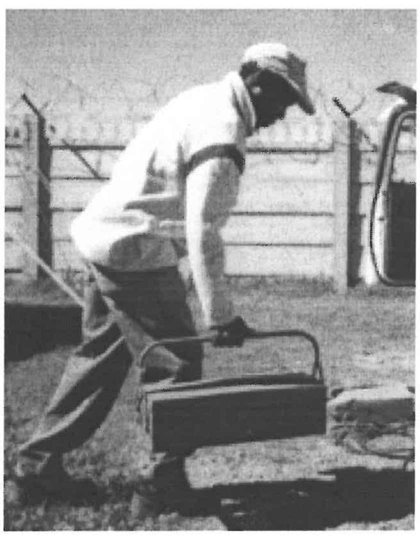


Photo 3.4: Working with a spanner at eye level:

3.4. Test battery design (including pilot study):

The tests to be used, as part of the test battery for this study, would attempt to test the four remaining movements/exertions as closely as possible, while using objective, quantitative measuring methods. It was decided that dynamometers would be used as far as possible as this method would be the most practical in "field-testing" and because a dynamometer can easily be used when designing new tests, as was the case in this study.

Each of the four movements were carefully examined, taking note of body angles, the thickness of gripping areas, the width of the tools being used, the directions in which the exertions take place, etc. The goal was to design tests that are as work-specific as possible, but still objectively measurable. It was also important to ensure that the tests were valid and reliable.

The test battery consisted of six tests, namely:

(1) arm strength above the head;
(2) lifting strength from the floor (right hand);
(3) lifting strength from the floor (left hand);
(4) adduction strength;
(5) shoulder endurance at eye level (right hand); and

(6) shoulder endurance at eye level (left hand).

After the careful design of each of the six tests, including the finalising of standard test descriptions, testing procedures, and an informed consent form to be filled in by each employee before testing, a pilot study was performed to ensure the validity and reliability of the tests.

3.4.1. Pilot study:

The pilot study consisted of three testing sessions on three different groups of workers. The goal was to see how the actual physical work performance of each participating employee (as observed by his/her co-workers and supervisor) compared to his/her physical performance in the tests. This was done by ranking the employees in each group, according to their actual physical outputs in the field, and then doing a correlation study between the way they were ranked and the way they performed in each test. This way the validity of each test could be determined and adjustments could be made where necessary.

The ranking was done by getting the group that`s to be tested, and their supervisor, together before the testing started. Firstly, the group was asked to give two nominations for the worker whom they consider to be physically the strongest in their group, in terms of the physical tasks they perform every day. After the two favourite nominations were given, the group was asked to vote for the one they consider to be the strongest on the job. Once this was done, the winner got the number one ranking and the loser went back into the group. The next step was to get two nominations for the number two position. Once again the group voted, the winner got the number 2 ranking and the loser went back into the group. This process was continued until each of the group members had a ranking.

The next step was to gather all the relevant information and have each participant fill in and sign an informed consent form. Then the testing started, first the physiological tests for safety screening (blood pressure, resting heart rate, BMI, etc.), then the six physical work specific tests. After the completion of the tests, the total work specific score was worked out for each participant by adding up the scores achieved in each of the six work specific tests. The result is that each participant had seven test scores.

The final step was to determine the correlation between each of the seven tests (which included the total score) and the ranking list of the group. This was done by listing the participants according to their rank, with each participant`s seven test scores next to his/her name. In order to ensure "positive" correlation coefficients, each person received a score according to his/her rank. If the group consisted of ten participants, for example, the number one ranked worker received a "10", the number two ranked a "9", the number three ranked an "8", etc. These new numbers, in stead of the ranking order numbers, were used during the correlation calculations between the ranking list and each test. The correlation studies were done, using Pearson`s correlation coefficient as well as Spearman`s correlation coefficient. Spearman`s correlation coefficient is generally considered to be the preferred method when working with ranked data and smaller groups (Howell, 1992).

3.4.1.1. Pilot group one:

The first group tested as part of the pilot study, consisted of 10 participants. The correlation results showed that a few of the tests required adjustments in order to improve reliability and validity. Especially the two "shoulder endurance" tests (left and right) required some rethinking. Minor adjustments were also made to the "adduction" test and to the "lifting strength from the floor" tests (left and right) as the execution of these tests raised suspicion about their performance reliability. It is also important to note that "shoulder endurance – left" was not tested in the first pilot group as time was limited and the original "shoulder endurance" tests were extremely time consuming. This also resulted in motivational aspects playing too big a part, with participants stopping due to boredom rather than muscle fatigue. A few vital changes were subsequently made to the "shoulder endurance" tests. Table 3.3 shows the results of both correlation coefficients when comparing each test to the ranking list.

Table 3.3: Correlation coefficients for pilot group 1 when comparing results of each test with the ranking list:

	Pearson	**Spearman**
Strength above the head	0.954	0.976
Lifting strength from floor - Right	0.769	0.663

Lifting strength from floor – Left	0.835	0.894
Arm adduction strength	0.889	0.903
Shoulder endurance – Right	0.727	0.766
Shoulder endurance – Left	N/A	N/A
Total work specific score	0.906	0.879

3.4.1.2. Pilot group two:

The second group tested consisted of 8 participants. The same procedure was followed as with group one, but minor changes have been made to the mentioned tests. See table 3.4 for correlation results.

Table 3.4: Correlation coefficients for pilot group 2 when comparing results of each test with the ranking list:

	Pearson	**Spearman**
Strength above the head	0.846	0.898
Lifting strength from floor - Right	0.901	0.922
Lifting strength from floor – Left	0.858	0.857
Arm adduction strength	0.828	0.850
Shoulder endurance – Right	0.865	0.952
Shoulder endurance – Left	0.868	0.934
Total work specific score	0.965	0.976

3.4.1.3. Pilot group three:

Even though the correlation results of pilot group two was satisfactory, it was decided to test one more group as part of the pilot study. The results were once again satisfactory, except for "shoulder endurance – left" which showed a marked decrease in correlation. It must be reported, however, that one of the strongest participants in pilot group three complained of pain in the left shoulder shortly after the test started and as a result decided to stop his effort early. This group consisted of 10 participants. See the correlation results in table 3.5.

Table 3.5: Correlation coefficients for pilot group 3 when comparing results of each test with the ranking list:

	Pearson	Spearman
Strength above the head	0.817	0.915
Lifting strength from floor - Right	0.938	0.964
Lifting strength from floor – Left	0.937	0.948
Arm adduction strength	0.893	0.939
Shoulder endurance – Right	0.886	0.875
Shoulder endurance – Left	0.611	0.419
Total work specific score	0.957	0.976

3.5. Test descriptions:

After the pilot study was completed, the six tests to be used in the "work specific" test battery were considered to be valid and reliable. Here follows the tests that were designed and used during the study, including photos, equipment used and detailed descriptions.

3.5.1. Test 1: Arm strength above the head:

3.5.1.1. Photos:

Photos 3.5 & 3.6: Anterior view of "arm strength above the head":

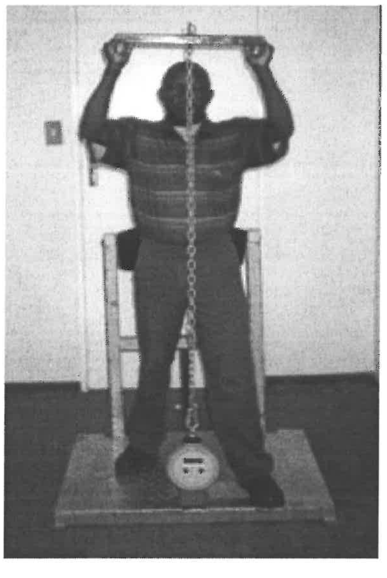
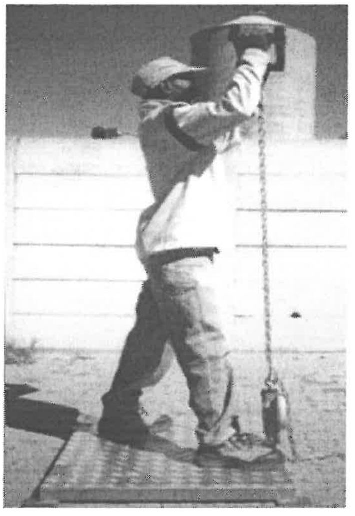


Photo 3.7: Lateral view of "arm strength above the head":



3.5.1.2. Equipment:

The following equipment was used for this test:

(1) iron handle bar – specifically designed for this study;

(2) 2.5 meter chain (attached to handle bar);

(3) steel clip (caribbeener);

(4) back-&-leg electronic dynamometer from Takei, and

(5) 100 cm X 80 cm steel platform.

3.5.1.3. Test description:

- The subject stands on the steel platform with both feet facing the front edge of the platform (dynamometer). The feet are a little more than shoulder width apart when viewed from the front, with the toes of one foot (any foot) touching the front edge of the platform and the heel of the other foot close to the back edge of the platform. The legs are straight at all times. This provides a steady base to push from.
- The upper body, neck and head are in a straight line and should remain like that throughout the test.
- The arms are in front of the body with angles of approximately 90 degrees at the shoulder joints and at the elbow joints (before pushing).
- The hands firmly grab hold of the handle bar on opposite sides of the bar, with the broad sides of the bar facing the front and the back. The handle bar must be directly above the dynamometer.

- The subject holds the starting position while the test administrator connects the chain to the dynamometer with the steel clip. It is important to make sure that the subject is still in the correct position when the chain (now connected to the dynamometer) is straightened.
- The subject now pushes the handle bar straight upwards against the dynamometer, with maximum effort, by using the arms and the shoulders.
- Two maximum efforts are performed and the highest score (in kg force) is recorded.
- The test administrator must be positioned alongside the subject to ensure that there`s no backward "leaning" during the efforts.

3.5.2. Test 2: Lifting strength from the floor (left and right):

3.5.2.1. Photos

Photo 3.8: Anterior view of "lifting strength from the floor" (left hand):

Photo 3.9: Lateral view of "lifting strength from the floor" (left hand):

3.5.2.2. Equipment:

The following equipment was used for this test:

(1) grip – specifically designed for this study;
(2) 50 cm chain;
(3) back-&-leg electronic dynamometer from Takei, and
(4) 100 cm X 80 cm steel platform.

3.5.2.3. Test description:

- The subject will perform this test on both sides of the body. The photos show the test being performed with the left hand holding the grip (dynamometer on the left side of the body) and the description will describe it as such. Exactly the same guidelines are to be used with the right hand gripping (other side of the body). Therefore all the guidelines still apply, but with the opposite side of the body, the opposite edge of the platform, etc.
- The subject stands on the platform with the left side of the body facing the front edge of the platform (dynamometer). The foot that`s closest to the front edge of the platform (the left foot in this case) is placed in the front right corner of the platform. The foot that`s closer to the back edge of the platform (the right foot in this case) is placed directly in front of the right hip joint, with the toes of the right foot touching the left edge of the platform. This starting position is very important, as it will assist the subject in pulling straight up, preventing him/her from "leaning" and using the body weight in stead of muscle strength when pulling.
- The subject firmly grabs hold of the grip in his/her left hand and now bends both legs to lower the grip (and the chain that`s attached to it) towards the dynamometer. The upper body stays virtually straight to prevent excessive strain on the spine and its muscles when the pull is performed (a slight anterior and lateral tilt towards the dynamometer is permitted).
- The chain is attached to the dynamometer and the starting position is quickly rechecked by the test administrator.
- The subject now pulls straight upwards against the dynamometer, pushing upward with the legs and holding onto the grip at all times (leaning is not permitted).
- Two maximum efforts are performed and the highest score (in kg force) is recorded.

- The test administrator must be positioned directly behind the subject to ensure that there`s no sideways leaning during the efforts.

3.5.3. Test 3: Arm adduction strength:

3.5.3.1. Photos:

Photo 3.10: Anterior view of "arm adduction strength":

Photo 3.11: Lateral view of "arm adduction strength":

3.5.3.2. Equipment:

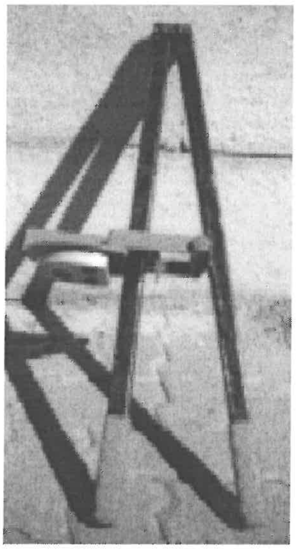
The following equipment was used for this test (see photo 3.12):

(1) adduction bars – specifically designed for this study;

(2) electronic grip dynamometer from Takei, and

(3) 4 steel clips (to fasten dynamometer onto adduction bars).

Photo 3.12: Adduction bars with grip dynamometer in place (ready for use):



3.5.3.3. Test description:

- The subject stands with his/her back against a wall. The body must remain virtually straight throughout the test and the wall assists in checking for this.
- The subject firmly grips the adduction bars on the two rubber grips, with the narrow end pointing away from the body.
- The bars must remain at an upward angle of approximately 45 degrees at all times. The "adjustable cross bar" that's used in the "shoulder endurance" test can be used to ensure this, by resting the narrow end of the adduction bars on the cross bar and adjusting the height to ensure a 45 degree angle. The adduction bars must touch the cross bar at all times.
- The hands are held at "belt level" (approximately at the same height as the anterior superior spina illiacas) and should remain at that height throughout the test.

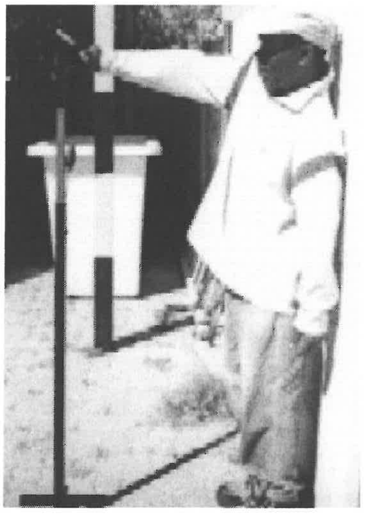
- The subject now attempts to push the handles together with maximum force, causing an "arm adduction" action.
- Two maximum efforts are performed and the highest score (in kg force) is recorded.
- The test administrator must be positioned alongside the subject to ensure that there`s no excessive flexing of the trunk during the efforts.

3.5.4. Test 4: Shoulder endurance at eye-level (left and right):

3.5.4.1. Photos:

Photo 3.13: Anterior view of "shoulder endurance at eye-level" (right shoulder):

Photo 3.14: Lateral view of "shoulder endurance at eye-level" (right shoulder):



3.5.4.2. Equipment:

The following equipment was used for this test:

(1) 6 kg weight;
(2) stop watch; and
(3) adjustable cross bar.

3.5.4.3. Test description:

- The subject stands with his/her back against a wall.
- The adjustable cross bar is placed directly in front of him/her and the cross bar is adjusted to exactly the same height/level as the eyes of the subject.
- Now the subject is asked to make a fist and extend his/her arm (right arm first) straight in front of him/her until the shoulder joint is at 90 degrees. The adjustable cross bar is moved away from the subject until the subject`s fist is exactly under the crossbar. The crossbar is now at the correct height, the correct distance, and exactly in front of the subject (splitting him/her in half).
- The subject is now given the 6kg weight in his/her right hand and asked to raise the hand that`s holding the weight with a straight arm until the back of the hand touches the cross bar (the palm of the hand must face down at all times).
- The moment the back of the hand touches the cross bar, the test administrator starts to measure the time with the stopwatch. The goal is to keep the hand against the bottom edge of the cross bar for as long as possible. The moment the hand drops away from the cross bar, breaking contact, the stopwatch is stopped and the time is recorded.
- Exactly the same procedure is followed with the left hand.
- The test administrator must be positioned straight in front of the subject, keeping the eyes on the same level as the point where the hand is touching the crossbar.
- Only one maximal attempt is performed with each arm.

3.6. Testing procedures:

A standardised testing procedure was used in order to ensure reliability and repeatability of test results.

3.6.1. Pre-testing procedures:

On arrival at the venue, the biokineticist firstly prepared the testing area (any large area or room was used). Five testing stations were prepared, as well as an area where all the participants could be seated. The five stations were set up as follows:

(1) station for height and weight assessment (general information);
(2) arm strength above the head;
(3) lifting strength from the floor;
(4) arm adduction strength; and
(5) shoulder endurance at eye level.

The next step was to get all the employees at the venue together and to brief them on a few important points concerning the tests and the testing procedures. The group was asked to take their seats in the area with the chairs. The whole group was then informed of the following:

- the reasons for the testing;
- how the testing will take place (stations, groups, etc.);
- how each test will be performed (demonstrations);
- important pointers on each test;
- what will be measured with each test;
- the link between each test and the work they do in the field; and
- the importance of the informed consent form and the relevant "safety" questions.

The informed consent forms were handed out next and each person was asked to complete his/her form. The whole group completed this at the same time and the test administrator thoroughly went through the form with the group, clarifying each question and ensuring that all participants understood the importance of their co-operation in answering each question truthfully. Finally the "consent" paragraph was read and explained, and each participant was asked to sign the form (if he/she was satisfied and willing to participate) and write in the date of the assessment. Table 3.6 shows an example of the informed consent form used.

Table 3.6: Informed consent form for work specific physical assessments:

Informed consent for work specific physical assessments:

1. Do you suffer from high blood pressure? YES___NO___
2. Have you ever been told that you have high blood pressure? YES___NO___
3. Do you presently take any medication for high blood pressure? YES___NO___
4. Have you injured your back in the last 6 months? YES___NO___
5. Do you suffer from pain in your lower back at present? YES___NO___
6. Have any heart problems ever been diagnosed? YES___NO___
7. Do you suffer from pains in the chest or heart? YES___NO___
8. Do you have a hernia? YES___NO___
9. Have you had any operations in the

Wrists	Yes		No	
Arms	Yes		No	
Legs	Yes		No	
Back	Yes		No	

10. Is there any other reason why you cannot perform the physical evaluation?

____
____
____
____

I was fully informed about the purpose and procedure of the physical evaluation and agree to participate willingly. I will perform the tests to the best of my ability. In the event of any unforeseen injury during the tests, I shall not hold the testing official or the company responsible or liable for such instances.

Signature: ____________________

Date: ____________________

After the completion and signing of the informed consent forms, the evaluation forms were handed out and the participants were asked to complete the personal information section. See Table 3.7 for an example of the evaluation forms used.

Table 3.7: Evaluation form for work specific physical assessments:

WORK SPECIFIC PHYSICAL ASSESSMENTS

Initials		**Surname**	
Unique No.		**Date**	
Division		**Site location**	
Group		**Gender**	
Section		**Biokineticist**	
Department		**Time**	
Job Title		**Age**	

					COMMENTS
Height (cm)					
Weight (kg)					
Resting heart rate (beats/min)					
Resting systolic BP (mmHg)					
Resting diastolic BP (mmHg)					

Strength above head (kg)					
Strength from floor – right (kg)					
Strength from floor – left (kg)					
Arm adduction strength (kg)					
Shoulder endurance – right (time)	sec				
Shoulder endurance – left (time)	sec				

Description of injury or illness (if any):

____

____

____

____

3.6.2. Procedures during testing:

Once the personal information section was completed, everyone remained seated and the blood pressures and resting heart rates of the whole group was tested. During this, the informed consent forms were also checked for relevant information. If any problems were identified through the answers of a participant, the biokineticist dealt with it accordingly.

An individual was not allowed to take part in the physical evaluations if his/her resting systolic blood pressure was above 200 mmHg, or if the resting diastolic blood pressure was above 120 mmHg (American College of Sports Medicine, 1991).

After this "safety testing" was completed, the large group was divided into smaller groups of four per group. This was done for practical reasons. Firstly, because it was easier for the biokineticist to control a smaller group, and secondly, because the relevant supervisor could control which individuals he/she wanted to do the tests first, in the middle, or last. This allowed some individuals to finish the testing earlier and consequently they could then attend to general work emergencies and outputs while the rest of the employees were still being tested.

Each group was taken through all 5 testing stations before the next group started (this approach had to be followed as only one biokineticist administered the testing). The group was firstly asked to remove their shoes and excessive clothing, such as jackets and hats. This was important for accurate height and weight assessment at station 1. Stations 2, 3, 4, and 5 were subsequently visited where the work specific tests were performed in the sequence that was mentioned earlier and according to the methods described earlier.

A very important consideration was the matter of sufficient rest between tests. This was ensured by testing the four members of each group in the same sequence throughout all 5 stations. In other words, if a person were tested third at station 1, he/she would be tested third at all the following stations too. This ensured sufficient rest as approximately 5 minutes were spent at each station, allowing at least 3 or 4 minutes rest for each person between the tests. It was also very important to provide verbal encouragement for each participant, in order to ensure maximum effort at every attempt.

3.6.3. Post-testing procedures:

Post-testing procedures were extremely brief, as the participants of each group were thanked for their time and co-operation and the data forms were collected from each person. The members of each group were excused, once the evaluation forms were collected. The next group of four immediately proceeded to station 1 for the start of their assessments.

3.7. Research design:

3.7.1. Research topic:

Develop work specific minimum physical requirements (MPR) for blue-collar workers.

The research topic came about due to the identification of a gap in the work-related physical assessment of physical workers in SA ELEC.

3.7.2. Problem setting (research question):

What are the minimum physical requirements (MPR) for blue-collar workers within a specific department of a South African electricity supply companies` northern region when making use of work specific physical tests?

3.7.3. Hypothesis:

It is possible to calculate the minimum physical requirements (MPR) for blue-collar workers within the northern region of a South African electricity supply company by making use of objective, work specific physical tests.

An inductive approach was used during this study (Mouton & Marais, 1990; Neuman, 1997).

3.7.4. Study design:

This study can be described as cross-sectional (McBurney, 1994; Neuman, 1997), descriptive (Mouton & Marais, 1990; Edginton *et al.*, 1992; Neuman, 1997), and quantitative (Mouton & Marais, 1990; McBurney, 1994; Neuman, 1997) in nature. According to McBurney (1994) and Neuman (1997), a study is cross-sectional when a large group of people are tested at one point in time (within three months in the case of this study). Edginton *et al.* (1992) defines descriptive research as a systematic, factual and accurate description of an area of interest. Neuman (1997) explains that three possible goals of descriptive research are: (1) to provide an accurate profile of a group; (2) to give a numerical picture; and (3) to create a set of categories. The gathering of normative data is another example of descriptive research that is relevant to this study (Edginton *et al.*, 1992). Quantitative data collection can be described as the collection of data in the form of numbers, as was the case in this study (Mouton & Marais, 1990; McBurney, 1994; Neuman, 1997).

The two most important factors in the study design, as far as this study was concerned, was the identification of the test population and the selection of the sample that was to be tested. The test population for this study can be described as the blue-collar workers within a specific department of a South African electricity supply companies` northern region. The population consisted of 550 blue-collar workers and the initial approach was to select a representative sample group by making use of a random number table (McBurney, 1994; Neuman, 1997). This approach made sense at first, as the original plan was to test approximately 150 of the workers. Neuman (1997) states that for small populations (under a thousand), a researcher needs a sampling ratio of approximately 30% (165 workers in a population of 550). Due to favourable logistics, the possibility of improved reliability and validity, and the unpredictable nature of the work done by the target population (electrical breakdowns can force any worker to leave his/her workstation at any time), it was eventually decided that a sample group would not be chosen before hand. Instead, as many of the target population as possible would be tested. One can say that the testing took place at random, however, as the only criteria for being tested was that the employee had to be part of the 550 target population and he/she had to be present at the relevant work station on the morning of the testing. The test administrator had no say as to who would be tested at each work station and all 550 workers therefore had an equal chance of forming part of the study (McBurney, 1994; Neuman, 1997).

3.7.5. Data collection:

Three hundred and fifty six of the 550 target population was tested (65%). Twenty-six different workstations were visited in the data collection process. The work specific tests battery (with the six tests mentioned earlier) was used to assess each participant. After discarding the data of those subjects with missing values due to injury/illness and excluding the outliers from the data for improved representability, the test results of three hundred and forty four workers were used for the statistical calculations. This number is considered to be representative of the target population (Neuman, 1997).

3.7.6. Data analysis and interpretation:

The primary goal of this study was to develop minimum physical requirements (MPR) for the target population, using the new work specific tests. Once all the data had been gathered, the steps to follow had to do with the arrangement, manipulation, analysis, and interpretation of the data. The following steps were followed:

(1) capture all the data on Excel (computer program);
(2) discard the data of those subjects with missing values due to injury/illness, as well as the data of the outliers;
(3) use all the data (6 tests, as well as the total scores of all six tests) and arrange the data according to percentiles;
(4) break the percentiles up into increments of 5%;
(5) calculate the mean, median, mode, and standard deviation for each test, as well as for the total scores;
(6) draw up a histogram for each test and for the total scores, to indicate the distribution of variables against the normal curve; and
(7) calculate the minimum physical requirement (MPR) for each test and for the total scores.

3.7.7. Summary of the course of this study:

(1) Do a proper study of the relevant literature.
(2) Determine the exact target population.
(3) Do a thorough job analysis of each job within the target population to identify physical jobs and physical work outputs.
(4) Identify physical tasks through interviews and questionnaires.
(5) Identify the relevant movements and exertions that`s important in performing these tasks through observations, practical experience, and video analysis.
(6) Design a work specific test battery for the identified movements and exertions that will compliment the existing physical "factor" tests in use in SA ELEC.
(7) Do a pilot study to improve the validity and reliability of the work specific test battery.
(8) Collect data by testing as many of the target population as possible.
(9) Analyse and interpret data to calculate minimum physical requirements (chapter 4 takes a closer look at the steps that were followed in order to calculate the minimum physical requirement for each test and the results gathered from these calculations).

CHAPTER 4: RESULTS:

4.1. Statistical analysis (including calculation of minimum physical requirements):

As explained in chapter 3, all the data was captured on Excel (computer program), and the data of those subjects with missing values due to injury/illness, were discarded. This left the data of exactly 350 subjects to work with. A histogram was drawn up for each test, as well as for the total scores (each subject`s total score when adding all 6 tests together) to indicate the distribution of the variables against the normal curve. The histograms showed a number of outliers in the data and this caused most of the distributions to be positive skew. The reason for this was that the scores of a few individuals were much higher than that of the rest, and the question of "representability" was raised. It was decided that these individuals and the scores they achieved, were not typical of the target population and that their values had to be removed in order to achieve a more "normal" curve. A further 6 subjects were removed from the database, leaving the data of 344 subjects.

After removing the data of the outliers, the distribution for each test appeared to fit the conditions of a "normal" distribution far closer. Figures 4.1 to 4.7 show the distributions.

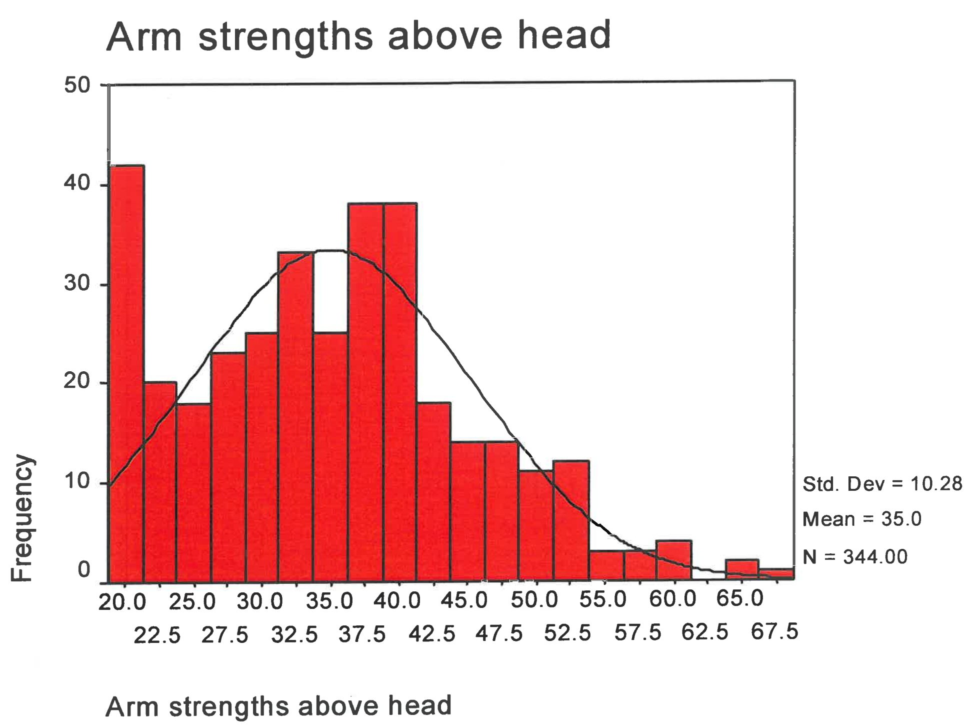


Figure 4.1: Distribution of variables for "arm strength above the head"

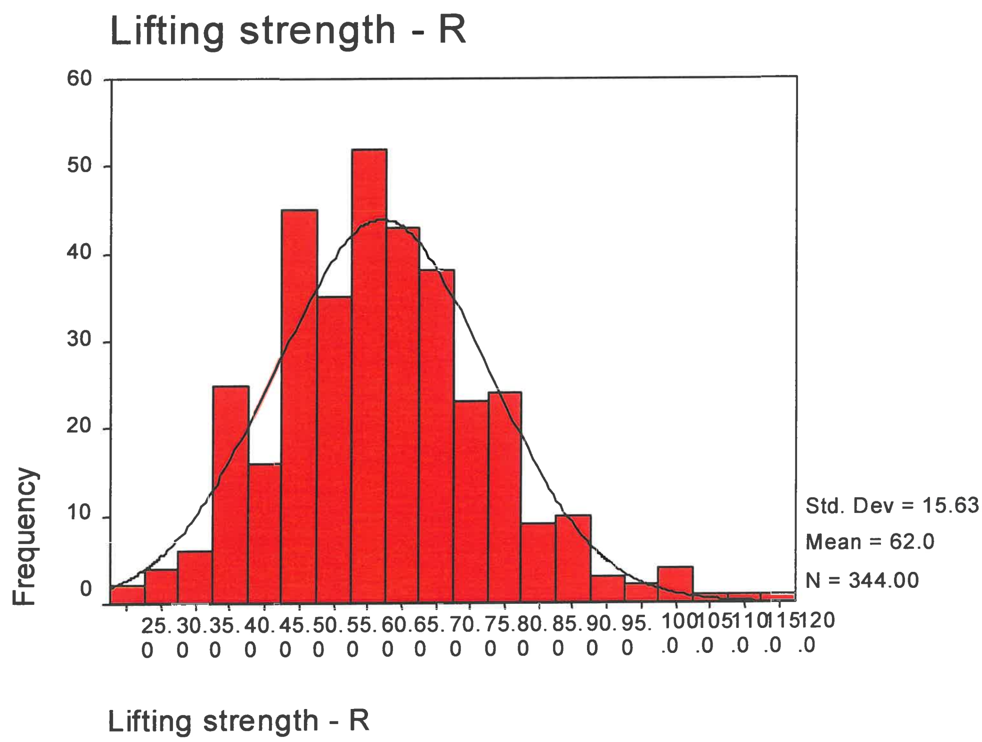


Figure 4.2: Distribution of variables for "lifting strength from the floor – right"

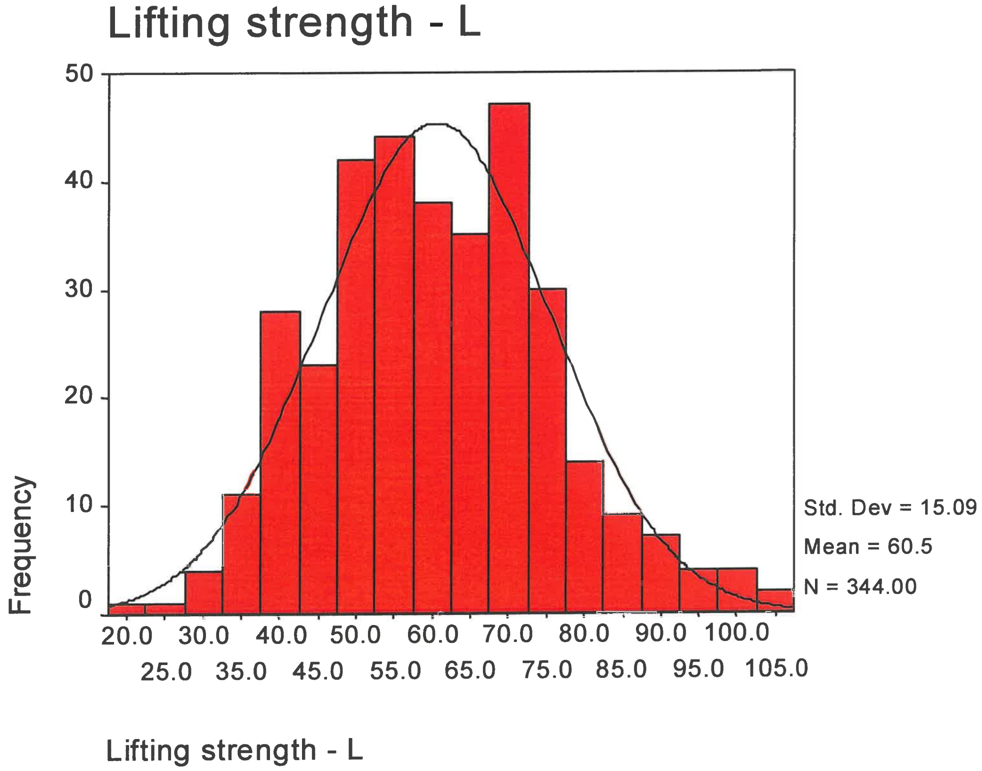


Figure 4.3: Distribution of variables for "lifting strength from the floor – left"

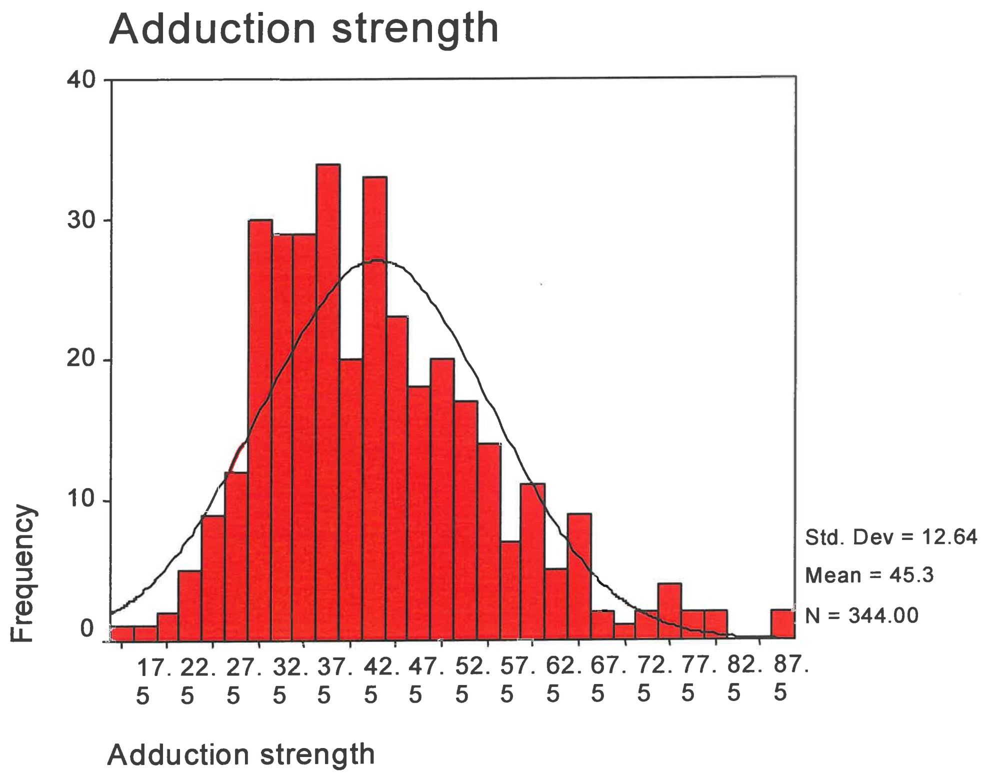


Figure 4.4: Distribution of variables for "arm adduction strength"

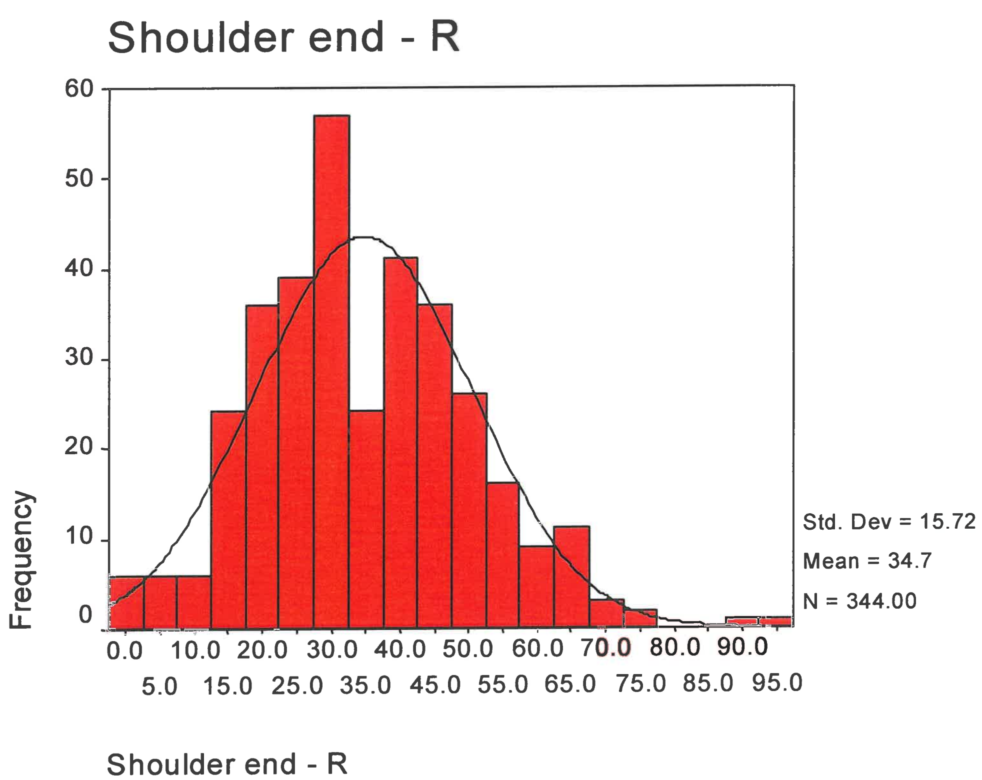


Figure 4.5: Distribution of variables for "shoulder endurance at eye level - right"

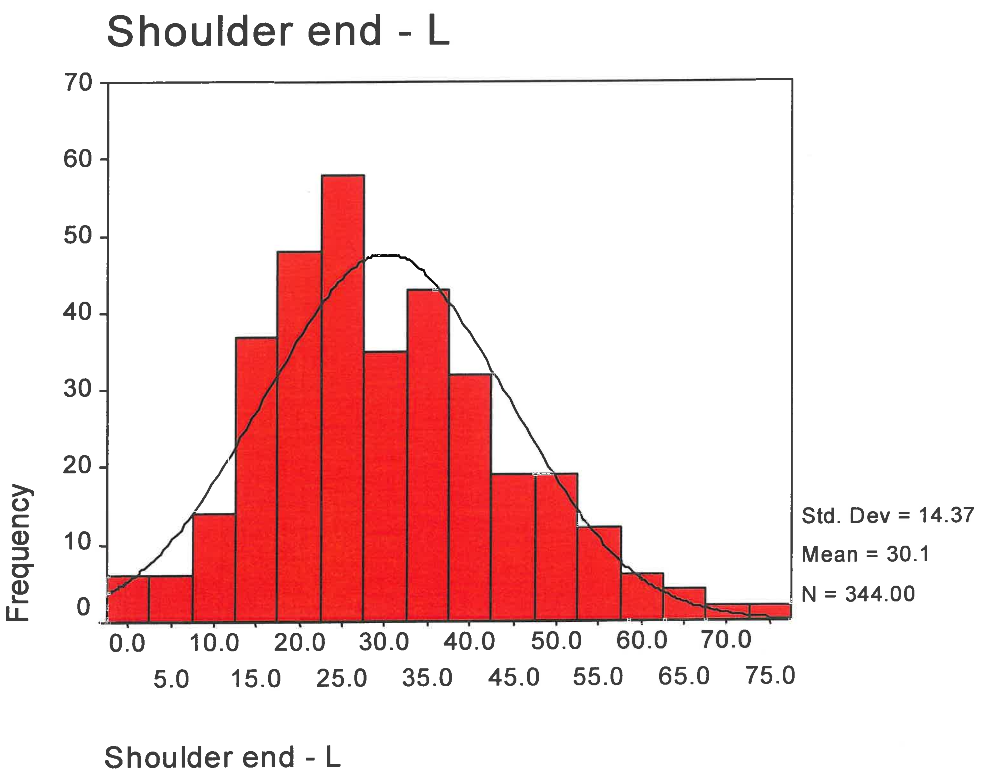


Figure 4.6: Distribution of variables for "shoulder endurance at eye level - left"

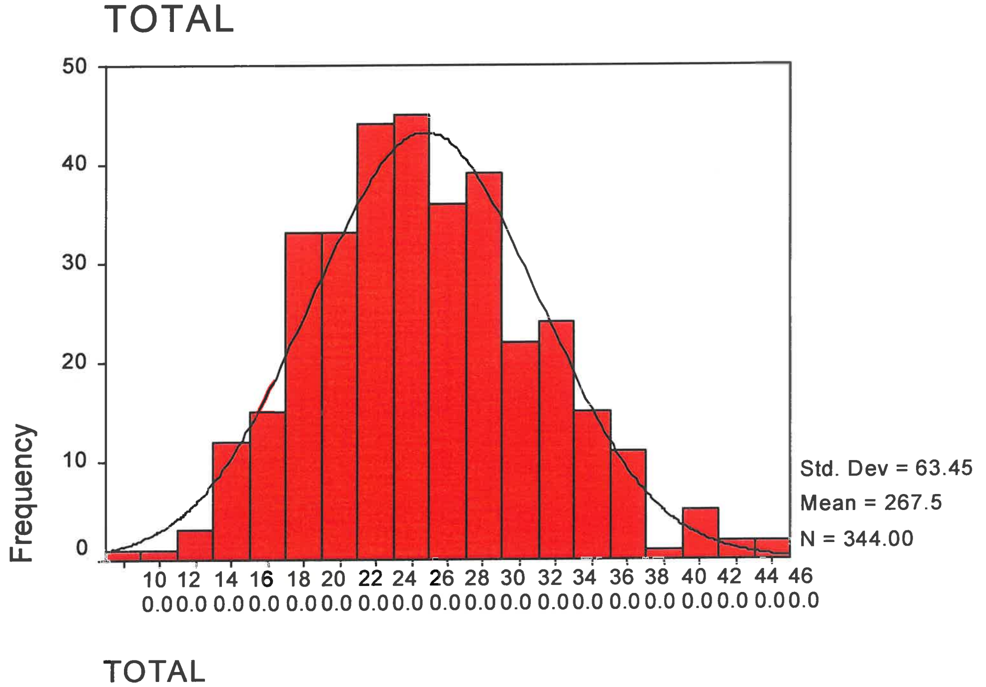


Figure 4.7: Distribution of variables for "total of six tests"

With the data now more "representative" of the target population and the distribution of the test data resembling more "normal" curves, the next step was to arrange the data according to percentiles, to show the variation and the distribution of the data, and to break the percentiles up into more manageable increments of 5%. Table 4.1 show the percentiles in increments of 5%.

Table 4.1: Data of 344 subjects as percentiles in increments of 5%:

%	Arm strength above head	Lifting strength R	Lifting strength L	Arm adduction strength	Shoulder endurance R	Shoulder endurance L	Total of six tests
100	68.5	120.5	103	91	96	77	454.1
95	53	90.75	88.5	68.5	63	56	372.6
90	49	81.5	78.5	62.2	55	50.6	350.3
85	46	78.6	76	58	50.25	46	336.3
80	43	74.5	72.5	55	48	42	323.1
75	40.8	71.4	71	52.5	45	39	308.3
70	40	67.5	69	50.4	43	36.8	298.5
65	38.6	67	67	48.2	41	34	290.4
60	37.5	65	65	46.4	39	33	280.4
55	36.5	62.5	61.5	45.25	36	30.2	272.25
50	35	60.5	60	43.75	32	28	264.2
45	33.5	59.5	57.5	42	31	25.8	254.8
40	32	57.5	55.5	40	29	24	248.5
35	30.3	55.9	53.5	39	28	23	239.8
30	28.75	53	51.5	37.7	25	22	232.4
25	26.5	51	49.5	35.9	23	20	219.7
20	25	50	47.5	34.6	22	18	210.2
15	23	45.75	43.9	32.9	19	16	201.3
10	20.5	41.75	40.5	31.7	16	14	191.75
5	20	39	37.1	28.6	10.5	11	170
0	< 20	< 39	< 37.1	< 28.6	< 10.5	< 11	< 170

As was the case with the percentiles, the mean, median, mode, and standard deviation for each test, as well as for the total scores, could be calculated once it was established that the data is a true reflection of the target population. These measures of central tendency and variation were important as they were used to help calculate the minimum physical requirements (MPR). Table 4.2 show these values. It is important to note that in instances where multiple modes exist, the smallest value is shown in table 4.2.

Table 4.2: The mean, median, mode, and standard deviation for each test:

Statistics	Arm strength above head	Lifting strength (Right)	Lifting strength (Left)	Adduction strength	Shoulder endurance (Right)	Shoulder endurance (Left)	Total of six tests
N	344	344	344	344	344	344	344
Mean	34.98	61.99	60.46	45.33	34.71	30.09	267.48
Median	35.00	60.50	60.00	43.75	32.00	28.00	264.15
Mode	20.00	67.50	54.50	36.70	29.00	23.00	210.00
Std deviation	10.275	15.627	15.092	12.639	15.719	14.369	63.449

The final step was to calculate the minimum physical requirement (MPR) for each test, as well as for the total scores. What approach to follow in this regard was a tricky question. On the one hand, a purely objective and statistical approach would raise questions about the practical relevance of the MPR, and on the other hand, a purely subjective approach would raise serious questions about the lack of a scientifically viable explanation for the MPR. It was decided to try and find a middle way and to involve both statistical and practical information in calculating the MPR of each test.

With the measures of variation and central tendency already calculated, it was decided to gather information from people who are both experts in the kind of work being performed by the target group, as well as the physical abilities required of workers to perform the relevant tasks sufficiently. The idea was to compare the practically based feedback from these experts with the scientifically based statistical values that were already in place. The hope was that some similarities or tendencies would be present, and that these similarities or tendencies would provide support for the final conclusions.

The eight workstations (depots) where the most employees were tested during the data collection phase were identified for the purpose of gaining practically based feedback. The employees tested at each work station, were ranked from best to worst according to the total score of each employee (six tests added together). The supervisor at each of the eight work sites received a ranked list with only the names and "unique numbers" of those employees that work at his/her site and that were tested during data collection. It was explained to the supervisors that they were required to assist in setting work-related minimum physical requirements (MPR) for the physical jobs within the relevant department. The compilation of the list was explained to each one of them and they were asked to each pick one employee on the list, who would be considered a good "cut-off point" when thinking in terms of minimum physical ability that is necessary to perform the physical side of the job adequately. The following question was put to them: "If you were to appoint a new employee for the purpose of performing the relevant physical tasks adequately, to which employee on the list should the new employee be equal in terms of minimum physical ability (at least as physically capable as ....)?". Only a name and unique number was asked from each supervisor in return.

Of the eight supervisors, six replied with a name (and unique number) from their depot, which they considered to be a good minimum ("cut-off") in terms of work-related physical ability. The test scores of these six employees were pulled from the database and listed in a table format. Table 4.3 shows the scores of the selected employees.

Table 4.3: The test scores of the six employees chosen by the supervisors as "employees with minimum physical ability":

	Arm strength above head	**Lifting strength (Right)**	**Lifting strength (Left)**	**Adduc-tion strength**	**Shoulder endu-rance (Right)**	**Shoulder endu-rance (Left)**	**Total of six tests**
A	31	62	72	42.1	42	32	281
B	40	64.5	69.5	39.7	56	46	316
C	35	80	89.5	43.5	49	62	359
D	59	82.5	78.5	73.9	43	36	373
E	40	66.5	52.5	51.2	25	23	258
F	41.5	52	48	67.1	19	21	248.6

Using the data in table 4.3, the average for each test was calculated in order to determine the average "subjective" score for that test. Before this could be done, however, the outlier values had to be removed. The means and the standard deviations that was calculated for the group of 344 were used to determine which values would be regarded as outliers. For each test, the standard deviation was added to the mean as well as subtracted from the mean. This left a bottom value and an upper value for each test. Every score lower than the bottom value or higher than the upper value was removed from the table and the remaining scores were used to calculate an average "subjective" score for each test. Table

4.4 shows the bottom- and upper value for each test, as well as the remaining scores that were used to calculate the average for each test.

Table 4.4: The test scores of the six employees chosen by the supervisors as "employees with minimum physical ability", excluding outliers. Included are the bottom- and upper values for each test, and the average "subjective" score for each test:

	Arm strength above head	**Lifting strength (Right)**	**Lifting strength (Left)**	**Adduction strength**	**Shoulder endurance (Right)**	**Shoulder endurance (Left)**	**Total of six tests**
Upper	45.26	77.62	75.55	57.97	50.43	44.46	330.93
Lower	24.71	46.36	45.37	32.69	18.99	15.72	204.03
A	31	62	72	42.1	42	32	281
B	40	64.5	69.5	39.7	-	-	316
C	35	-	-	43.5	49	-	-
D	-	-	-	-	43	36	-
E	40	66.5	52.5	51.2	25	23	258
F	41.5	52	48	-	19	21	248.6
Average	37.50	61.25	60.50	44.13	35.60	28.00	275.90

The next step was to compare the averages in table 4.4 (based on the feedback from the supervisors), with the statistical data from the large group of 344. Table 4.5 provides a visual comparison of the average "subjective" score for each test, with the statistical data (measures of central tendency) of each test.

Table 4.5: Visual comparison of the average "subjective" score for each test, with the statistical data (measures of central tendency) of each test:

Colour code

Average "subjective score"

Mean

Median

Mode

Graphs

%	Arm strength above head	Lifting strength R	Lifting strength L	Arm adduction strength	Shoulder endurance R	Shoulder endurance L	Total of six tests
100	68.5	120.5	103	91	96	77	454.1
95	53	90.75	88.5	68.5	63	56	372.6
90	49	81.5	78.5	62.2	55	50.6	350.3
85	46	78.6	76	58	50.25	46	336.3
80	43	74.5	72.5	55	48	42	323.1
75	40.8	71.4	71	52.5	45	39	308.3
70	40	67.5	69	50.4	43	36.8	298.5
65	38.6	67	67	48.2	41	34	290.4
60	37.5	65	65	46.4	39	33	280.4
55	36.5	62.5	61.5	45.25	36	30.2	272.25
50	35	60.5	60	43.75	32	28	264.2
45	33.5	59.5	57.5	42	31	25.8	254.8
40	32	57.5	55.5	40	29	24	248.5
35	30.3	55.9	53.5	39	28	23	239.8
30	28.75	53	51.5	37.7	25	22	232.4
25	26.5	51	49.5	35.9	23	20	219.7
20	25	50	47.5	34.6	22	18	210.2
15	23	45.75	43.9	32.9	19	16	201.3
10	20.5	41.75	40.5	31.7	16	14	191.75
5	20	39	37.1	28.6	10.5	11	170
0	< 20	< 39	< 37.1	< 28.6	< 10.5	< 11	< 170

It is clear from table 4.5 that the average "subjective" scores were very closely related to the mean and the median of each test. At no test do the subjective scores differ more than 10 percentile points from either the mean or the median. It was decided to calculate the minimum physical requirements (MPR) for each test by making use of the average of these three measurements. The MPR would therefore combine both the practical experience of the supervisors and the scientifically based measures of central tendency.

Table 4.6 summarises the three values that will be used for each test, and also provides the MPR for each test.

Table 4.6: Calculation of the MPR for each test:

Statistics	**Arm strength above head**	**Lifting strength (Right)**	**Lifting strength (Left)**	**Adduc-tion strength**	**Shoulder endu-rance (Right)**	**Shoulder endu-rance (Left)**	**Total of six tests**
Mean	34.98	61.99	60.46	45.33	34.71	30.09	267.48
Median	35.00	60.50	60.00	43.75	32.00	28.00	264.15
Subjective	37.50	61.25	60.50	44.13	35.60	28.00	275.90
MPR	35.83	61.25	60.32	44.40	34.10	28.70	269.18