CHAPTER 5: DISCUSSION OF RESULTS:

5.1. Participant statistics:

Three hundred and fifty six employees from the chosen department were assessed for the purpose of this study. The first part of this chapter will create a picture of this group of employees by presenting the general/personal data that was gathered and comparing it to the general/personal data of the subjects of other similar studies. The information used was gathered during the visits to the different venues, through the "safety tests" (pre-testing) and the applicable forms. This is an important exercise, as it will give the reader a good idea of the make up of the target population.

5.1.1. Gender

The department that was focussed on is male-dominated, purely because of the physically challenging work being performed on a daily basis. Studies by Balogun *et al.* (1991) and Alaranta *et al.* (1994) show that males usually perform better than females in muscle strength- and muscle endurance tests, which explains the low percentage of female workers, within the relevant department, to some extent. Figure 5.1 show that 99.44% of the employees assessed for this study, were in fact male. It is interesting to note that most other studies that focussed on blue-collar workers seemed to include a much larger percentage of female participants. One reason for this could be that South African companies are still reluctant to employ women in traditionally "males only" jobs, and this could be due to the fact that most South African companies do not have the tools that are required for fair selection in place. Here follows the male and female percentages that were reported for three similar international studies:

1. 80.94% males and 19.06% females (Chaffin *et al.*, 1978);
2. 67.47 % males and 32.53% females (Campion, 1983; Jackson, 1994); and
3. 73.73% males and 26.27% females (Kelsh & Sahl, 1996).

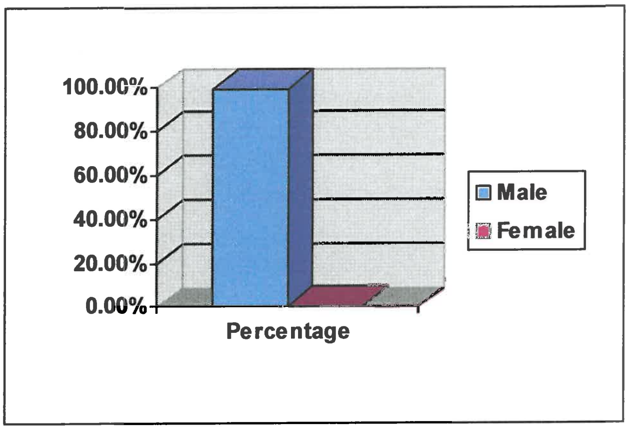

Figure 5.1: Gender

5.1.2. Race

This study also focussed on the Northern Region of SA ELEC. The Limpopo Province make up a large part of this region and it is well known that of all the provinces in South Africa, the Limpopo Province have the highest percentage of black people. Add to this the fact that physical jobs in South Africa have always attracted the black population to a much larger extend and it comes as no surprise that a very large percentage of the assessed group were black. Figure 5.2 show that 93.82% of the assessed employees were black. No literature could, however, be found to compare this percentage with. Jackson (1994) does mention a study on fire fighters that showed no significant differences in the way white and black firemen performed in a battery of job-specific physical tests.

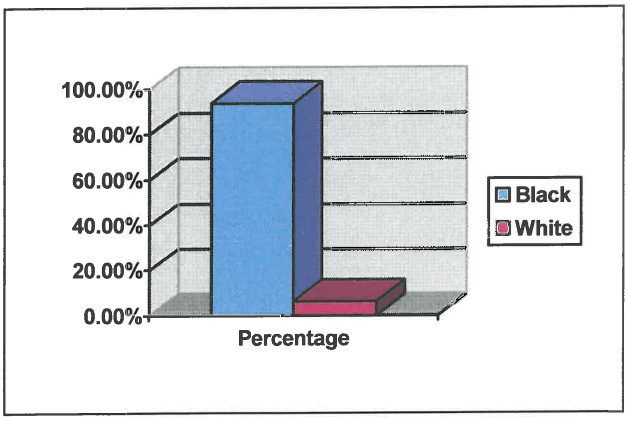

Figure 5.2: Race

5.1.3. Age

Figure 5.3 show the age distribution of the assessed employees. Most of the assessed employees were between 30 and 49 years of age, with 42.98% between 40 and 49, and 26.69% between 30 and 39 years of age. 3.08 % of the employees were older than 60 and 5.90% were younger than 30 years of age. The average age of the assessed group was 43.22 years. A study by Balogun et al. (1991) to gather grip strength normative data, involved a group of 960 people with an average age of 39.2 years. Alaranta et al. (1994) conducted a study on 508 white- and blue-collar employees, aged between 35 and 54 years, to gather normative data for non-dynamometric trunk performance tests. The age distribution in their study was as follows:

(1) 25.89% of the employees were between 35 and 39 years of age;
(2) 28.63% of the employees were between 40 and 44 years of age;
(3) 22.53% of the employees were between 45 and 49 years of age; and
(4) 22.95% of the employees were between 50 and 54 years of age.

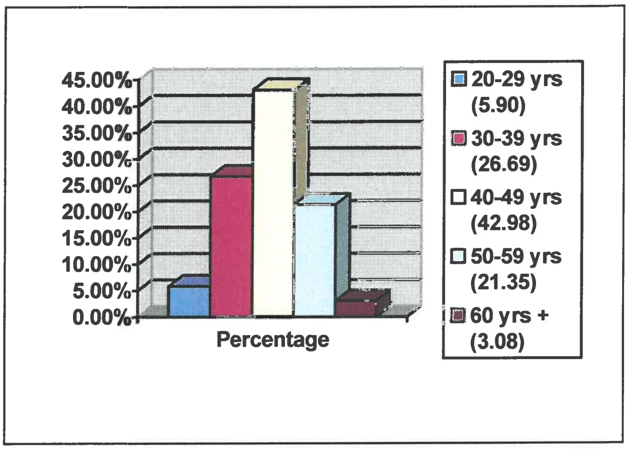

Figure 5.3: Age

5.1.4. Height

Figure 5.4 show the height distribution of the assessed employees. Most of the assessed employees were between 160.1 and 180 centimetres tall, with 40.45% between 160.1 and 170 centimetres, and 39.33% between 170.1 and 180 centimetres. The average height was 170.74 cm. In a study by Brownlie et al. (1985) the focus fell on the selection of fire fighter recruits. Height was measured as part of a test battery that was used to establish an ability profile for each recruit. The average height reported in 1982, 1983, and 1984 was exactly 180.6 cm each year. Magnusson et al. (1996) did a study on Swedish and American truck- and bus drivers and found the average heights to be 179.9 cm and 177.6 cm respectively. The average height of men in the United States of America was estimated at 177 cm and that of women at 162 cm (Adams, 1994). Erasmus (2003) found that the average height of male police officials in the SAPS is 176 cm and that of female police officials is 161 cm. The fact that the average height in this study seem to be much lower than that recorded in other studies, could be attributed to the fact that a number of the participating employees were Vendas. Vendas are generally small in stature.

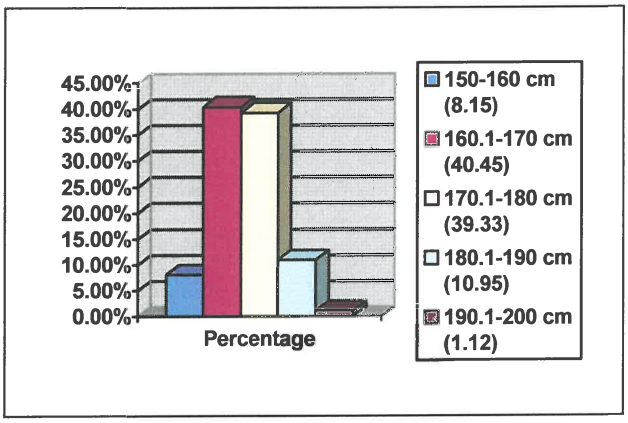

Figure 5.4: Height

5.1.5. Weight

Figure 5.5 show the weight distribution of the assessed employees. Most of the assessed employees weighed in somewhere between 60.1 and 90 kilograms, with 27.81% weighing between 60.1 and 70 kilograms, 26.40% weighing between 70.1 and 80 kilograms, and 16.02% of the assessed employees weighing between 80.1 and 90 kilograms. The average weight was 74.11 kg. In the study by Brownlie et al. (1985) on the selection of fire fighter recruits, the average weight reported in 1982, 1983, and 1984, were 78.8 kg, 78.7 kg, and 81.1 kg respectively. Magnusson et al. (1996) did a study on Swedish and American truck- and bus drivers and found the average weights to be 78.3 kg and 83.0 kg respectively. The average weight of men in the United States of America was estimated at 78 kg and that of women at 65 kg. The average weight of male and female officials in the SAPS is 82 kg and 64 kg respectively (Erasmus, 2003). The low average weight in this study can once again be attributed to the number of Vendas that participated. Vendas are generally of slight built.

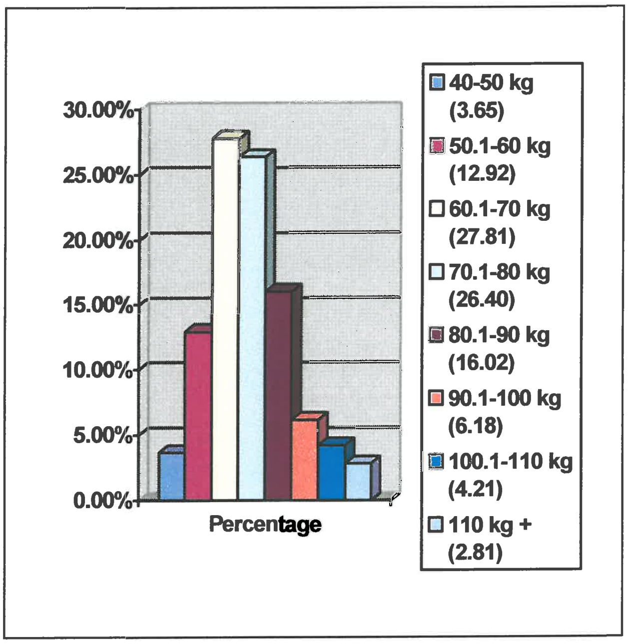

Figure 5.5: Weight

5.1.6. Resting systolic blood pressure

Figure 5.6 show the resting systolic blood pressure distribution among the assessed employees. Only 9.83% of the assessed employees had resting systolic blood pressures above 140 mmHg. 4.21% of the employees fell between 141 and 150 mmHg, 3.09% between 151 and 160 mmHg, and only 2.53% of the employees had resting systolic blood pressures above 161 mmHg. The highest systolic blood pressure recorded was 172 mmHg. According to Meyer and Meij (1992) and Martini (1995), the usual criterion for high systolic blood pressure in an adult is when the resting systolic blood pressure is greater than 140 mmHg. If any participant had a resting systolic blood pressure of 200 mmHg and above, he/she would not have been allowed to participate in the physical assessments.

The American College of Sports Medicine (1991) gives the following categories for systolic blood pressure in adults: (1) low systolic blood pressure when < 100 mmHg;

(2) normal systolic blood pressure when 101 – 129 mmHg; (3) high normal systolic blood pressure when 130 – 139 mmHg; (4) mild systolic hypertension when 140 – 159 mmHg; (5) moderate systolic hypertension when 160 – 179 mmHg; (6) severe systolic hypertension when 180 – 209 mmHg, and (7) very severe systolic hypertension when > 210 mmHg.

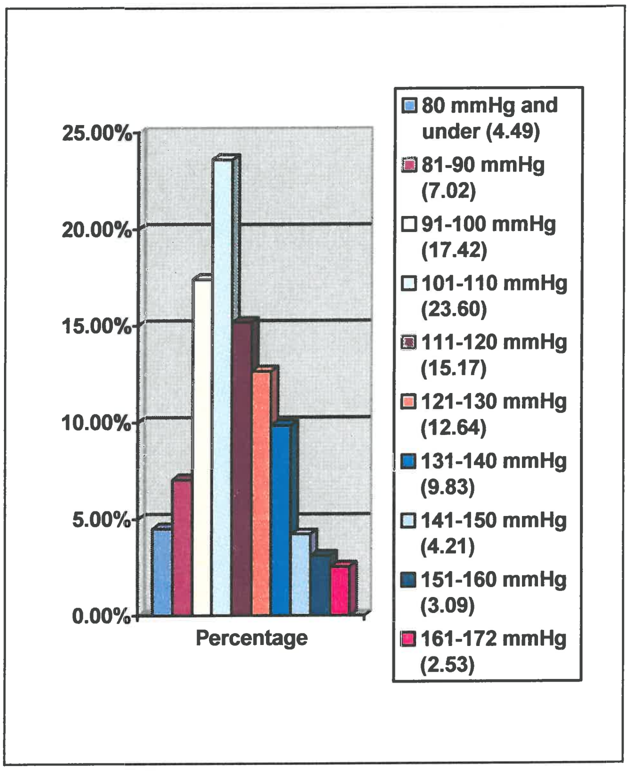

Figure 5.6: Resting systolic blood pressure

5.1.7. Resting diastolic blood pressure

Figure 5.7 show the resting diastolic blood pressure distribution among the assessed employees. Only 10.68% of the assessed employees had resting diastolic blood pressures above 90 mmHg. 7.87% of the employees fell between 91 and 100 mmHg, and only 2.81% of the employees had resting diastolic blood pressures above 101 mmHg. The highest diastolic blood pressure recorded was 125 mmHg. According to Meyer and Meij (1992) and Martini (1995) the usual criterion for high diastolic blood pressure in an adult is when the resting diastolic blood pressure is greater than 90 mmHg. If any participant had a resting diastolic blood pressure of 120 mmHg or above, he/she was not allowed to participate, due to the nature of the work-specific tests (isometric and maximal exertion).

The American College of Sports Medicine (1991) gives the following categories for diastolic blood pressure in adults: (1) low diastolic blood pressure when < 65 mmHg; (2) normal diastolic blood pressure when 66 – 84 mmHg; (3) high normal diastolic blood pressure when 85 – 89 mmHg; (4) mild diastolic hypertension when 90 – 99 mmHg; (5) moderate diastolic hypertension when 100 – 109 mmHg; (6) severe diastolic hypertension when 110 – 119 mmHg, and (7) very severe diastolic hypertension when > 120 mmHg.

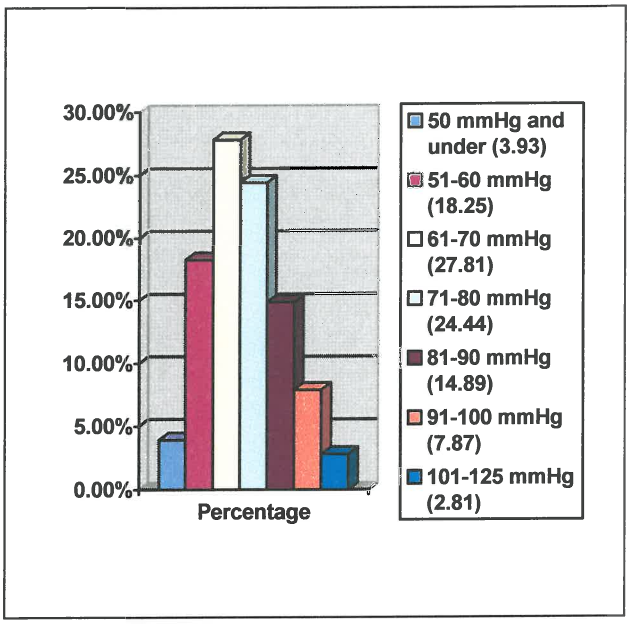

Figure 5.7: Resting diastolic blood pressure

5.1.8. Resting heart rate

Figure 5.8 show the resting heart rate distribution among the assessed employees. 24.72% of the assessed employees had resting heart rates between 61 and 70 beats per minute, and 36.24% of the assessed employees had resting heart rates between 71 and 80 beats per minute. According to Arnheim and Prentice (1993) a normal resting pulse rate for adults ranges between 60 and 80 beats per minute. It is, however, important to note that the extrinsic controls of cardiac function, such as nerves and chemicals within the blood, can cause the heart rate to speed up in "anticipation", even before the start of physical activity (McArdle et al., 1996).

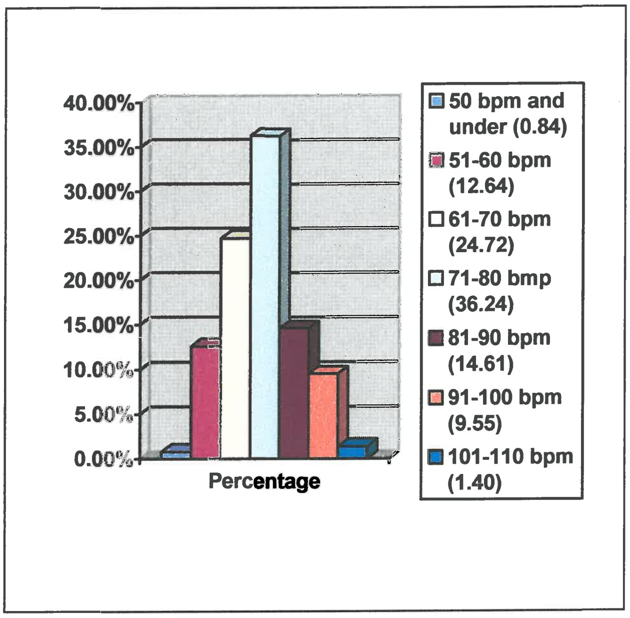

Figure 5.8: Resting heart rate

5.1.9. Orthopaedic problems

Figure 5.9 show the orthopaedic problems (recent and current) that were reported by the assessed employees. In 91 of the cases, one or more orthopaedic problem was reported. In the cases where more than one orthopaedic problem was reported, only the primary / most serious problem was used for this calculation. Back problems (59 cases / 64.8% of the 91 cases) were the most common, followed by shoulder- (12 cases / 13.2% of the 91 cases) and knee (9 cases / 9.9% of the 91 cases) problems. In a study by Mital & Pennathur (1999) on musculoskeletal injuries in American industry, it was found that the construction industry and the manufacturing industry produce the most cases of musculoskeletal injuries every year, with the construction industry leading the way. When looking at musculoskeletal injuries in all major U.S. industries during 1996, 38% of the injuries were injuries to the trunk, and 27% were injuries to the back. Upper extremity injuries, were the next highest category of injuries with 23% (Mital & Pennathur, 1999). Magnusson et al. (1996) conducted a study on occupational drivers (trucks and busses) to determine the risk for the development of musculoskeletal disorders in such occupations. Of a sample of 365 men, they found that roughly 50% of the subjects reported low back pain and roughly 25% reported shoulder pain. In a study on electricity utility workers, most injuries to males were experienced in the upper extremities, followed by injuries to the lower extremities, head- and neck injuries, and back injuries, in this sequence (Kelsh & Sahl, 1996).

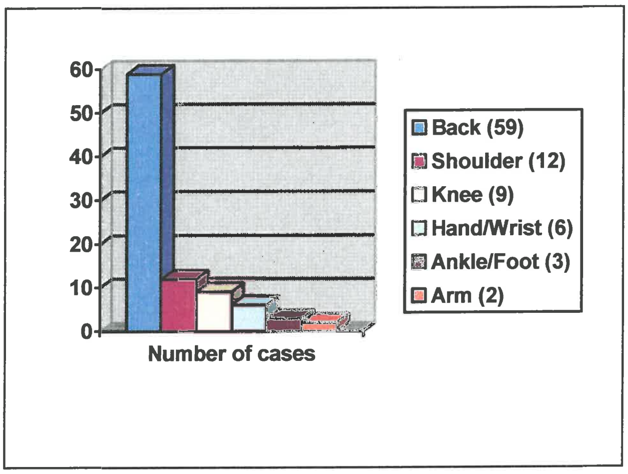

Figure 5.9: Orthopaedic problems

5.1.10. Special population problems

Figure 5.10 show the special population problems (recent and current) that were reported by the assessed employees. In 73 of the cases, one or more special population problem was reported. In the cases where more than one problem was reported, only the primary / most serious problem was used for this calculation. Of the 73 cases, 45 suffered from hypertension (61.6%), 11 were obese (15.1%), 9 had known cardiac problems (12.3%), 6 had abdominal hernias (8.2%), and 2 suffered from diabetes mellitus (2.7%). Unwin et al. (1998) did a cross sectional study on a sample of 322 men from the general British population, aged between 25 and 64 years. All the participants were selected from the register of the Newcastle Family Health Services Authority. 41.8% of the participants suffered from hypertension, 14.5% were obese, 9.8% had known cardiac problems, 7.1% suffered from vascular disease, and 1.9% suffered from diabetes mellitus.

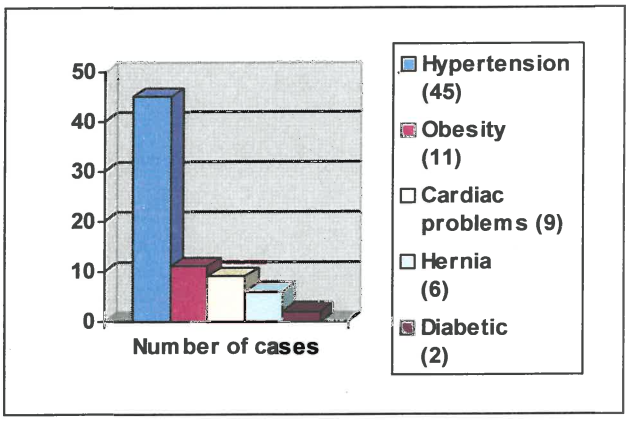

Figure 5.10: Special population problems

5.2. Correlation between "factor tests" and "work-specific tests" in SA ELEC:

It has been mentioned that SA ELEC already has a tool in place for the measurement of physical ability in physical workers. It has been explained that this existing tool focuses on the important physical "factors", in stead of work-specific tests, as was the case in this study. Because of the fact that this study focussed on SA ELEC employees, "factor" data was also available for most of the participating employees. It was decided to randomly select three of the depots where tests were conducted during this study (by blindly drawing three depot names), to use both sets of data for the participating employees from these depots and to do a Pearson correlation to see how the results from the two test batteries correlate. Firstly the employees with data in both sets of tests were identified, then the employees with missing data, due to injury or illness on the assessment days, were taken out to leave only those employees with two sets of complete data. The next step was to calculate a total "factor point" for each employee (using an existing SA ELEC computer program), as well as a total "work-specific point" by calculating the total of six tests for each employee. Next, the participants of each depot were sorted according to their "work specific point", from best to worst. The "factor point" for each employee was then recorded next to his / her "work-specific point" to leave two columns of data for each depot, with only the "work-specific" column sorted from best to worst. Here follows the sets of points, as well as the Pearson correlation, for each selected depot (see tables 5.1, 5.2, and 5.3).

Table 5.1: Two sets of points and Pearson correlation for depot A:

Participants	Work-specific points (sorted)	Factor points
1	448.5	66.4
2	441.6	62.86
3	436.5	85.7
4	372.9	70
5	346.1	47.9
6	339.7	57.9
7	339.5	52.1
8	326.6	70.7
9	266.6	20.7
Pearson correlation = 0.731266843		

Table 5.2: Two sets of points and Pearson correlation for depot B:

Participants	Work-specific points (sorted)	Factor points
1	525.9	80.7
2	516	85.7
3	350.3	62.14
4	302.6	62.9
5	296.7	60.7
6	291.7	66.4
7	285.9	72.1
8	250.8	47.9
9	248.6	46.4
10	190.8	33.6
11	164.7	33.6
Pearson correlation = 0.892736913		

Table 5.3: Two sets of points and Pearson correlation for depot C:

Participants	Work-specific points (sorted)	Factor points
1	379.2	46.43
2	366.7	62.14
3	323.1	50.71
4	298.9	52.14
5	275	65.71
6	269	45
7	258.2	38.57
8	238.8	37.86
9	233.4	32.14
10	213.2	38.57
11	201.9	30
12	149.9	23.57
Pearson correlation = 0.759368632		

5.3. Minimum physical requirements for work-specific tests:

The primary purpose of this study was to establish minimum physical requirements for a battery of work-specific physical tests. Table 5.4 gives a graphical presentation of the final product. Comparisons with other similar tools, as well as the uses of this tool, will be demonstrated in the remainder of chapter 5.

Table 5.4: The Minimum Physical Requirements Sheet (MPRS):

MPR	35.83	61.25	60.32	44.40	34.10	28.70	269.18

%	**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

The tests that were used in this study were brand new and were specifically designed for the purpose of this study. It is, therefore, impossible to compare actual results since no other study has made use of these tests. Similar studies, with minimum physical requirements for similar (but different) tests, will however be used to compare the tests used, the attributes tested, the methods used to calculate the minimum physical requirements, and the uses for the end products.

Bernauer and Bonanno (1975) mentions the following physical factors as part of the physical ability test battery used by them in their study on the development of physical profiles for jobs: (1) arm strength; (2) trunk strength; (3) stamina; (4) balance; and (5) response. SA ELEC currently use eight physical factor tests in their physical factor tests battery: (1) 3 minute step-up test (cardiovascular fitness); (2) isometric grip strength - right; (3) isometric grip strength - left; (4) isometric arm/shoulder muscle strength; (5) isometric back muscle strength; (6) isometric leg muscle strength; (7) sit-and-reach (flexibility); and the (8) one minute sit-up test (abdominal endurance). Greenberg and Bello (1996) made use of more work-specific type tests in their functional capacity test battery, designed as part of a work hardening program: (1) lifting; (2) carrying; (3) static pushing and pulling; (4) kneeling; (5) crawling; (6) crouching; (7) repetitive squat; (8) standing; (9) walking; (10) stair climbing; (11) ladder climbing; (12) trunk flexion; and (13) trunk rotation.

Bernauer and Bonanno (1975) made use of the mean score of each test to determine their minimum physical requirements. SA ELEC made use of a combination of mean scores, professional opinion ratings and worker inputs to determine the minimum physical requirements for the factor test battery. Greenberg and Bello (1996) used the actual physical demands required by the applicable job to calculate pass/fail scores for each of their functional tests. The methods used to calculate the minimum physical requirements for this study were described in chapter 4.

5.3.1. Discussion and demonstration:

With the final product "on the table", the next steps are to discuss the potential uses of such a tool and to demonstrate how it should be used.

5.3.1.1. Potential uses:

All the mentioned test batteries and their minimum physical requirements were developed for the same reason: To determine whether an individual possesses the physical ability to perform the physical tasks required of him / her in a specific physical job, effectively and safely (Bernauer & Bonanno, 1975; Greenberg & Bello, 1996).

Chapter 2 takes an extensive look at the uses and advantages of physical ability tests. The same uses and advantages apply for the work-specific tests. Pre-employment, re-employment, pre-placement, re-placement, physical profiling (of an individual or a department), early risk identification, evaluation of physical work capacity (of an individual or a department), etc. What makes this tool unique, however, is that it measures objectively and in a work-specific manner. If this method is used in conjunction with the traditional "physical factor" approach, it can be said that a holistic approach to physical ability testing is being followed.

5.3.1.2. Demonstration (including case study):

How does the tool work? The best way to demonstrate how the tool works is to do a case study. The data of one of the employees that were assessed during this study will be used for this purpose.

Mister B has been a SA ELEC employee for the past 8 years. He used to work as an administration clerk, until he decided to qualify himself as an electrician. During the time of the testing, he had already completed his theoretical and practical examinations and was working as a qualified electrician in the department that was selected for this study (northern region). His personal- and work-specific test data can be seen in Table 5.5 and Table 5.6 respectively.

Table 5.5 show that Mister B had no contra-indicating conditions during the time of the testing and that the tests didn`t hold any obvious physical dangers for him. He also had no history of hypertension, back injuries, back pain, heart problems, angina, hernias, serious operations, or any other significant illness or injury that would indicate that he shouldn`t have participated in the physical evaluation. He also agreed to perform the tests to the best of his ability.

Table 5.5: Informed consent form for Mister B:

Informed consent for work specific physical assessments:

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

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

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

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: **Mister B**

Date: **06 / 06 / 2002**

Table 5.6: Evaluation form for Mister B:

WORK SPECIFIC PHYSICAL ASSESSMENTS

Initials	**M**	**Surname**	**B**
Unique No.	**123456**	**Date**	**06/06/2002**
Division	**Distribution**	**Site location**	**Mokopane**
Group	**Engineering**	**Gender**	**Male**
Section	**Electrification**	**Biokineticist**	**X**
Department	**Electrification**	**Time**	**8h30**
Job Title	**Electrician**	**Age**	**31**

					COMMENTS
Height (cm)	**1**	**6**	**4.**	**5**	
Weight (kg)			**6**	**1**	
Resting heart rate (beats/min)			**6**	**8**	
Resting systolic BP (mmHg)		**1**	**3**	**0**	
Resting diastolic BP (mmHg)			**8**	**8**	

Strength above head (kg)			**3**	**4**	
Strength from floor – right (kg)			**7**	**6**	
Strength from floor – left (kg)			**6**	**8**	
Arm adduction strength (kg)		**6**	**3.**	**5**	
Shoulder endurance – right (time)		**21**		sec	
Shoulder endurance – left (time)		**18**		sec	

Description of injury or illness (if any):

N/A

Table 5.6 show Mister B`s general information, as well as the actual data recorded. The physiological data show that Mister B`s weight, resting heart rate, and resting blood pressure were all normal. Next, the work-specific test data of Mister B had to be plotted on the Minimum Physical Requirements Sheet (MPRS). Each work-specific test result, as well as the "total of six tests" (**280.5**), had be plotted in order to create a visual picture of the physical work capacity of Mister B. See Table 5.7.

Table 5.7: Mister B plotted on the MPRS:

MPR	35.83	61.25	60.32	44.40	34.10	28.70	269.18
Mr B	34	76	68	63.5	21	18	280.5

%	**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	21	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

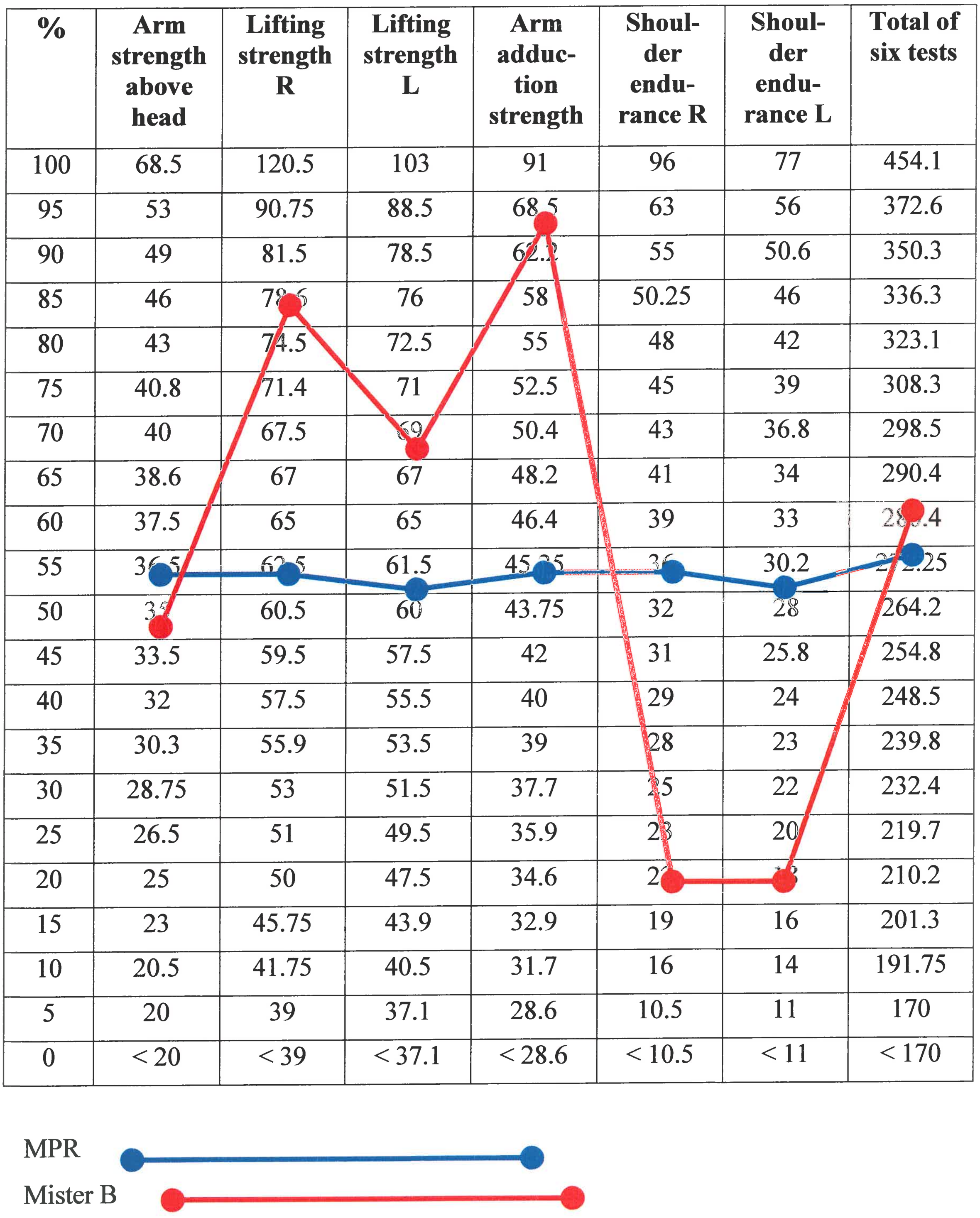

Table 5.7 show Mister B`s data, compared to the MPR for each test and the MPR for the "total of six tests". The "total of six tests" were firstly used to determine whether Mister B was considered to be above or below the overall MPR. The next step was to focus on each individual attribute in order to identify potential problem areas for the employee. The following 3 categories are used to classify an employee:

(1) above overall MPR (conditioning / rehabilitation **not** required);
(2) above overall MPR (conditioning / rehabilitation required); and
(3) below overall MPR (conditioning / rehabilitation required).

Mister B will fall in category 2. The reason for this is that his "total of six tests" score was above the MPR, and therefore he was above the overall MPR. He did, however, have 3 attributes below the respective MPRs and therefore he will require physical conditioning. He specifically requires shoulder strengthening as shoulder strength affects both "arm strength above the head" and "shoulder endurance at eye level" (the three tests where he didn`t make the MPR).

5.4. This study and SA ELEC:

It was mentioned throughout chapters 1, 3, and 4, that the work-specific tests were designed to compliment the factor tests that are already in use in SA ELEC by testing employees in a more work-specific manner. It was also demonstrated in chapter 3 how some of the critical movements / exertions that were identified, were already being assessed and that this study would focus on those critical movements / exertions that were not tested up to now. The next big question is "how will SA ELEC benefit from this holistic approach to assessing the physical abilities of physical workers?"

Here follows a list of potential benefits to the company:
- test results will be more relevant to the actual physical tasks performed on a daily basis;
- more suited employees can be employed;
- existing employees can be fitted to jobs that suit their physical abilities;
- more employees in need of rehabilitation / conditioning will be identified, due to the wider variety of tests;

- the progress of employees on conditioning / rehabilitation programs can be monitored in a more holistic and work-specific manner; and
- due to this more thorough method of testing, the biokineticists that work for SA ELEC could play a bigger part in the reduction of sick leave, ill-health applications, injury-on-duty claims, and employee turn-over rates, as well as in the improvement of productivity and employee satisfaction.

CHAPTER 6: SUMMARY, CONCLUSION AND RECOMMENDATIONS:

6.1. Introduction:

The primary purpose of this study was to identify and design a battery of work-specific physical tests for the physical workers (blue collar workers) within one of the departments of a South African electricity supply company (SA ELEC), and to establish work-specific minimum physical requirements (MPR) for the relevant jobs. The idea was to establish one powerful and complete measuring tool, which consists of MPR for the physical "factor" tests, that are already in use in SA ELEC, as well as MPR for the work-specific tests - the result of this study. The approach followed, included a literature search, followed by an extensive study that 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.

6.2. Summary of literature review:

6.2.1. The history of job-related physical assessments:

Internationally, job-related physical ability testing has taken some very interesting turns through the years (Davis & Dotson, 1987). With the advent of women entering what had been traditionally male dominated occupations, came the development of entry level tests (Washburn & Safrit, 1982; Davis & Dotson, 1987). New world wide laws concerning the employment of the disabled also showed a number of shortcomings in the procedures followed when selecting employees. Most of these procedures were misleading and irrelevant as they were based on assessments that showed little similarities with actual work requirements (Meier, 1998). Out of these and related considerations has arisen a new approach to the evaluation of potential employees, based on the concept of matching the functional capacities of the individual to the physical demands of the job (Fraser, 1992).

6.2.2. Job-related physical assessments and South Africa:

South Africa, as a still developing industrial country, relies heavily on the utilisation of manual labour and the idea of measuring physical work capacity is not a new one in the industrial world of South Africa (Hessel & Zeiss, 1988; Malan, 1992; Malan & Kroon, 1992). Constant development and implementation of new ideas is, however, necessary in order to improve the methods and the standards of physical work capacity measurement in order to ensure progress and conformance with the changes in the work environment (Malan, 1992; Malan & Kroon, 1992). According to research done in South Africa, numerous companies consider their manpower/human resources to be their most important asset. This implies that these companies strive toward employing only the best workers to ensure that they contribute positively to the productivity of the company. The success or failure of companies such as these greatly depend on the quality of worker that is being employed (Holder, 1992; Malan, 1992). This study will possibly make a contribution to the successful selection and maintenance of quality workers in South African companies.

6.2.3. Job analysis:

In the process of establishing test batteries and minimum physical requirements that are relevant to the physical jobs within a company and the critical physical tasks performed daily within these jobs, a thorough job analysis is vital as the starting point. Fleishman (1979) explains that the most important part of successful job-related physical testing lies in determining, through proper job analysis techniques, what the tasks of the job are and what abilities are relevant for performing the required tasks. 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.

Generally, there are four widely preferred methods when it comes to the analysis of a job and its physical ability requirements: (1) study the official, written job descriptions; (2) interview the workers to be tested; (3) video analysis; and (4) job-site assessments (Shrey & Lacerte, 1997; Meier, 1998; Toeppen-Sprigg, 2000).

6.2.4. Important considerations in developing job-related physical assessments:

After a thorough job analysis, the development of the test battery starts. According to Shrey & Lacerte (1997), there are a number of critical things to consider during this stage of proceedings: (1) the safety of the individuals to be tested; (2) internal and external test validity of the tests; (3) statistical reliability of the tests; (4) objective testing procedures, as apposed to subjective methods; (5) performance credibility; and (6) assessment standardisation.

There are also a number of more tangible considerations, namely: (1) what approach to measuring the physical requirements of a job one should use; (2) the number of tests one should use in a test battery; (3) the variety of variables one should assess; (4) the duration of the tests battery; (4) the expenses involved; (5) the physiological factors involved; (6) the legislation involved; (7) possible advantages to be gained; etc.

6.2.5. Strength measurement:

Human strength exertion capability is another very important consideration in the development of ergonomic guidelines for the screening of workers performing manual materials handling jobs (Karwowski & Mital, 1986). Muscular strength may be defined as the maximum force/tension a muscle or, more correctly, a muscle group can generate/exert against a resistance in one maximal effort/contraction (McArdle *et al.*, 1991; Arnheim & Prentice, 1993; Fox *et al.*, 1993; Corbin & Lindsey, 1994; Foss & Keteyian, 1998; Powers & Howley, 2001). A number of methods for measuring strength have been developed to allow the matching of muscular capabilities of workers with the force required of a particular job (Heyward, 1991; Newton & Waddell, 1993; Alaranta *et al.*, 1994). De Vries (1986), Corbin and Lindsey (1994), and Foss & Keteyian (1998), all state that in a physiological sense, there are generally four ways in which the contractile elements of muscle can produce force through the various bony levers available in the human body. They are (1) isometric contraction (static contraction); (2) concentric isotonic contraction (shortening); (3) eccentric isotonic contraction (lengthening); and (4) isokinetic contraction (with constant angular velocity of the limb segment). Each of these contractions is measured in a different manner.

6.2.6. Pre-placement assessments and the legal side of things:

Occupational health professionals have a significant role to play in the selection of suitable employees as well as in the management of incapacitated employees (Hogan & Quigley, 1986; Strasheim, 1996; Van Niftrik, 1996; Botha *et al.*, 1998; Botha *et al.*, 2000). Occupational health professionals share in the responsibility to guard against practices that may cause legal liability. It is therefore imperative that they are familiar with the possible legal repercussions of their activities as it relates to pre-placement testing (Botha *et al.*, 1998). A closer look at the Labour Relations Act 66 of 1995 and the Employment Equity Act 55 of 1998 gives the health professional a good idea of the possible pit falls when it comes to job-related physical ability testing.

The most important concept to grasp in this regard is that discrimination, based on the inherent requirement of a particular job, does not constitute unfair discrimination. By implication, unfair discrimination (from a medical or health point of view) will therefore exist where an applicant, on medical grounds, is found to be unsuitable for a particular position whilst his particular disability or affliction does not significantly diminish the applicant`s ability to perform the work. In other words, where the applicant`s medical condition does not impact on any inherent requirement for the specific job and the applicant is nevertheless unsuccessful as a direct result of his medical condition, the employer`s failure to appoint the applicant will constitute an act of unfair discrimination (Grogan, 1997; Botha *et al.*, 1998).

6.2.7. Possible advantages of job-related physical assessments:

Traditional "experts" on physical ability testing, such as Chaffin (1974) and Chaffin *et al.* (1978), have always supported the concept that the incidence and severity of musculoskeletal illness or injury can be reduced on jobs that require physical exertions. Through the years it has been proposed that such a reduction can be achieved by selectively employing workers who can demonstrate strengths in standardised tests which are as great or greater than that required in the normal performance of their jobs (Chaffin, 1975). In the course of this type of research, many basic and practical questions have been raised. Some of these questions have been answered sufficiently, most of them are still being debated (Waddell & Burton, 2001).

One point that is not debated, however, is the ever rising incidence of disability among the working population, in South Africa and abroad (Chavalinitikul *et al.*, 1995; Van Niftrik, 1996). Millions of rands/dollars are lost every year due to workers compensation claims (Lukes & Bratcher, 1990; Kroon & Malan, 1992; Greenberg & Bello, 1996). Low back pain has traditionally been the most costly industrial injury, with an estimated expense of over 8 billion dollars spent in the United States alone each year (Greenberg & Bello, 1996). According to Capodaglio *et al.* (1997), acute and chronic work-related injuries may be attributed to excessive force demanded by the task (especially by tasks such as lifting, carrying, pushing and pulling), inadequate osteoarticular structures, or insufficient general or local aerobic capacity. Early and regular physical ability testing could play a big part in reducing work-related injuries (Malan & Kroon, 1992).

Every company is primarily concerned with the bottom line. In other words, they want to see improvement in productivity, accident rates, turnover rates, absenteeism, sick leave, ill-health applications, etc., simply because these concepts are directly related to the profits of the company. The implementation of any fitness program in the workplace, usually depends on management`s acceptance that the program will be financially worthwhile (Greenberg *et al.*, 1995; Finch & Owen, 2001). Borofsky and Smith (1993) indicated in a study that a pre-employment screening inventory could result in significantly lower accident rates, turnover rates and absenteeism. Lubbe (2001) and Lubbe (2002) indicated that physical ability screening and subsequent intervention programs can result in higher productivity, as well as lower employee turn-over rates, less sick leave, and fewer ill-health applications.

6.3. Summary of the course of this study:

(1) Literature review.
(2) Identify the exact target population.
(3) Analysis of relevant job descriptions.
(4) Identification of physical tasks through interviews and questionnaires.
(5) Identification of relevant movements and exertions through observations, practical experience, and video analysis.
(6) Development of a work-specific test battery that will compliment the existing physical “factor” tests in use in SA ELEC.
(7) Pilot study to improve the validity and reliability of the work-specific test battery.
(8) Data collection.
(9) Analyses and interpretation of data.
(10) Calculation of minimum physical requirements.

6.4. Conclusion:

The conclusion of this study is twofold. Firstly, it was concluded that it is possible to develop a work-specific test battery that will complement the existing factor tests in SA ELEC, but also stand on its own legs as a powerful and valid test battery. Secondly, it was concluded that it is possible to calculate work-specific minimum physical requirements that can be used for reliable screening of the target population.

6.4.1. The work-specific test battery:

(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);
(6) shoulder endurance at eye level (left hand); and
(7) total of six tests.

6.4.2. The minimum physical requirements (see table 6.1):

Table 6.1: The minimum physical requirements of the work-specific tests:

Tests	Minimum Physical Requirements	SI
arm strength above the head	35.8	kgf
lifting strength from the floor (right)	61.25	kgf
lifting strength from the floor (left)	60.32	kgf
adduction strength	44.40	kgf
shoulder endurance at eye level (right)	34.10	sec
shoulder endurance at eye level (left)	28.70	sec
total of six tests	269.18	total

(kgf = kilogram force; sec = seconds)

6.5. Recommendations:

An assessments tool such as the one that will be implemented in SA ELEC from now on (involving both the "factor"- and the "work specific" approach) will allow the company to employ and maintain a work force that is physically capable of performing the critical physical tasks required of them, effectively and safely. It could allow the "blue collar" side of the company to operate at an optimal level for years to come and the financial benefits to the company should be vast.

This was, however, only a small step into what is very much unexplored territory in South Africa. For too many years have the selection and maintenance of physical workers in South Africa taken place in an unprofessional, unscientific manner. Is it only a coincidence that the leading industrial countries in the world are also the leaders in pre-employment assessment and physical work capacity screening? The time has come to open our eyes to the possibilities of improved selection- and screening methods. Any company with physical workers, that do not have tools such as these in place, is seriously limiting its own potential and is making itself more vulnerable to the potential consequences of a work force that is not physically able to perform their outputs on a daily basis.

It is strongly recommended that more research should be done on the assessment of physical ability in physical workers, and especially in the neglected field of work-specific physical ability testing. Here follows a few examples of related areas that are in serious need of more research:

(1) the development of alternative work-specific tests that will allow health professionals to assess all physical workers work-specifically;
(2) the development of test equipment that will enable health professionals to assess citical movements/exertions objectively and work-specifically;
(3) the development of new methods of job analysis;
(4) the development of new methods of test design;
(5) the development of new methods of calculating minimum physical requirements;
(6) research the validity and reliability of existing physical ability tests and test batteries;
(7) research the short- and/or long term benefits of pre-employment physical ability testing; and
(8) research the short- and/or long-term benefits of regular physical ability screening.