Chapter 6
Discussion

6.1 Overview

This study set out to assess the reliability of both the CST and ISWT. It also looked at whether the two tests were comparable in terms of percentage increases and also in terms of the O$_2$ pulse. The two tests are used at S&O NHS trust as assessments of an improvement of exercise capacity following an eight week cardiac rehabilitation programme. 33 patients completed this study, of these 7 were female and 26 were male with a mean age of 57.3 (+/- 11.54). The characteristics of these patients reflect the nature of cardiac disease, this being a mainly male and also an older population. Each patient was asked to complete the two different functional capacity tests on three separate days, firstly at the patient assessment appointment prior to attendance at the programme, secondly on commencement of the programme (within one week of the first test) and thirdly during the final session of the programme. Both CST and ISWT tests were performed on the same day with a rest period of at least 20 minutes between them, to allow the heart rate to return to normal. Patients were advised that as well as attending the twice weekly sessions they should exercise on at least one other day in line with BACR guidelines.

At the testing sessions distance in meters during the ISWT was measured and predicted VO$_{2\text{max}}$ during the CST was estimated following collection of the
data. Other variables measured were heart rate, and RPE. Ideally the CST requires 3 readings to measure VO$_{2\text{max}}$ on the graph but 19 of the 33 patients didn’t complete the 3 levels so the 2 readings were used.

6.2 Reliability

ISWT

The recommendations for performing the ISWT state that a practice test should be carried out in order to familiarise the participant with the test. The results from this study show that there is a learning effect from carrying out two ISWTs within one week with a mean increase in distance walked of 298.5m +/- 99m to 349.4m +/- 122m, this being statistically significant. This indicates there is a need for there to be a practice walk test to familiarise the participant with the test.

The difference between PT and FUT8 was 125.2m, and between the BT and FUT8 was 74.3m implying the increase of 50.9m was due to practice, familiarising the participant with the test.

The distance between the first and second tests increased significantly, the RPE only increased by 0.21, which is not statistically or clinically significant. The peak heart rate did not increase significantly between the two tests, and although statistically significant ($p = 0.044$), not clinically significant (96bpm to 99 bpm), suggesting that the increase in distance walked was due to familiarisation with the test rather than motivation. This confirms the need for the practice walk.
The hypothesis that “there will be no difference between the results for the practice ISWT and the test carried out at the first session pre-programme” was rejected.

CST
The CST duration varied between 4 minutes and 10 minutes, depending on the fitness of the individual. Some subjects reached 80% of their predicted maximum heart rate (those on beta-blockers had the maximum heart rate adjusted to take this into account), or had reached RPE 15 at the end of level 2 (4 minutes). At this point the test was terminated.

The CST manual does not suggest a practice test is carried out in order to familiarise the participant with the test. The results from this study showed a mean change in mls/kg from $28.9 \pm 7.97$ to $27.8 \pm 7.98$ this not being statistically significant.

The peak heart rate did not increase significantly between the two tests, and although statistically significant ($p = 0.00$), not clinically significant (104bpm to 107 bpm),

The difference between the two CSTs was not significant therefore the hypothesis that “there will be no difference between the results for the practice CST and the test carried out at the first session pre-programme” is accepted.

With limited time for performing a practice test the CST would be more reliable. A reason for this could be because it is possibly easier for participants to follow the stepping rate with the use of a metronome to allow
the person stepping to keep in time. There is also need for less space when conducting the CST.

Limits of Agreement

In table 5.5 it can be seen that there is a significant difference between the two distances measured at the practice test and the baseline test in the ISWT, the $p$ value being below 0.05 ($p=0.005$) but no significant difference between the CST as the $p$ value is above 0.05 ($p=0.801$). This is also reflected in the LoA, the agreement is much wider in the ISWT (this is very wide) and reflects poor reliability. The CST has much better agreement. In this context it may be more likely that if patients' scores changed in the CST this would be due to changes following an intervention and not due to poor reliability as seems to be the case with the ISWT.

In theory the second criteria to calculate LoA has been violated for the ISWT as LoA should not be calculated if there is a significant difference.

Errors

Potential sources of error included the use of a visual line of best fit, the prediction of maximum heart rate from 220-age, subtracting an additional 30bpm for those on beta-blockers, accurate reading and recording of heart rate and also the subject's ability to maintain the correct stepping tempo and technique, affecting mechanical efficiency. It was noted by Sykes and Roberts (2004) that in a small number of instances the pre-recorded instructions at each 2 minute stage caused the heart rate to momentarily elevate. The tester
therefore had to carefully monitor heart rate to ensure the correct heart rate was recorded. The tester had to ensure the subject maintained the correct stepping rate; deviations from the preset rhythms affect the exercise oxygen cost. The pre-recorded instruction to change leading leg occasionally required prompting from the tester within this study.

6.3 Comparability of the two tests

Pulse O₂

This indirect index of cardiopulmonary oxygen transport increased in both the ISWT and CST from the baseline to the post cardiac rehabilitation test at eight weeks as would be expected following exercise training. When compared individually the two different tests showed that the ISWT pulse O₂ had no difference between the baseline and follow up tests (0.12), but when calculating the pulse O₂ the distance achieved is used to estimate Mets and will lead to inaccuracies. For example someone walking 250 meters will have the same Met value as someone walking 320 metres. The estimated Met value for each level of the ISWT is an average and would in reality vary from person to person. The VO₂ is then calculated by multiplying the Met value by 3.5, to obtain a more accurate reading the actual VO₂ would need to be measured.

It would be expected that there would be an increase in exercise capability following an eight week exercise programme.
The ISWT distance walked increased from 349.4m +/- 122 to 423.6m +/- 121.9 meters. The difference in percentage change between the two tests was statistically significant $p<0.005$ which is a reflection in the increased exercise capacity of the participants.

The CST mls/kg increased from 29.5 ± 7.8 to 36.8 ± 9. The difference in percentage change between the two tests was statistically significant $p<0.005$ again reflecting the increased exercise capacity of the participants.

The results of the comparison of the ISWT and CST show that in this study they are equally useful as predictive measures of cardiovascular performance $p = 0.73$. Therefore the null hypothesis is accepted. This stated that “There will be no difference in the percentage change in recorded exercise capacity in the patients who have been enrolled and have completed the eight-week cardiac rehabilitation programme between the Incremental Shuttle Walk Test (ISWT) and the Chester Step Test (CST).”

Sensitivity to change in the context of a cardiac rehabilitation programme Following 8 weeks of CR showed there was a significant increase in ISWT and CST performance, suggesting an improvement in exercise tolerance. There was no control limb so comment cannot be made on why this change occurred. The ISWT and CST appear sensitive to changes in exercise tolerance following CR.
6.4 Test preference

Patients in this study preferred the ISWT this may be because it is a familiar activity; also this may be due to the fact that the ISWT starts at a lower work rate and therefore is easier. They also did not reach the same MET value on completion of the test. The ISWT starts at a Met value of 1.9 Mets and the CST at 3 Mets which would feel easier. There were no patients who refused to step. The hypothesis “patients have no preference between the two tests” was rejected.

6.5 RPE

Although teaching RPE to the patients is standardised within the cardiac rehabilitation programme, it is for some people a very difficult concept to understand. The RPE is only introduced for the majority of patients at the initial assessment and a handout given for home reference. From the responses to RPE during the tests (especially the practice) it is apparent that the scale is not fully understood. Although the CST did not require a practice test for reliability of VO₂ to use the RPE effectively they may need further practice. This is an area which could be looked at by future researchers.

Conclusions

The major findings of this study were that the ISWT requires a practice test for it to be reliable as a measure of exercise performance whereas the CST does not. The two tests (CST and ISWT) are equally useful as predictive measures of cardiovascular performance but this study has not assessed their validity.
The CST starts at a higher workload with the lowest step/slowest speed having an energy expenditure of 3 METS and the ISWT starting at less than 2 METS it would therefore be useful to compare a step test that started with the same MET values.

The ISWT showed some element of learning whereas the CST was reliable without a practice test. Therefore using the CST would alleviate the need for conducting three tests and be more cost efficient as well as needing less space to perform the test.

The implications drawn from this study are that results obtained from the two different test methods are interchangeable and comparable when using them as measures of change in exercise capacity. Both tests are reproducible, the ISWT needing the patient to become familiar with the test indicating both are ideal and highly reliable tools for monitoring change in exercise performance in response to a training programme.

RPE should be introduced at an early stage to allow the patients to be become familiar with this method of gauging physical activity effort. This may be able to be introduced when the patients are in-patients as they prepare for discharge.

Patients seem to prefer the walking test, this may be because it starts at a lower workload and it possibly is a more familiar activity.
Limitations

This study did not compare two tests which measure the same units. The CST estimates VO₂ max which can then be predicted by plotting the corresponding heart rate at different step levels with a minimum of 3 points, although it can be used with 2 points as in this study this may lead to error when plotting the graph. The ISWT measures distance travelled and speed reached it is therefore not directly comparing like with like. Plotting the heart rates was a problem in that some patients only reached the second level giving only two points to plot, anyone who only reached level 1 would have had to be excluded from the study. Considering this patient group there are many patients with low fitness levels who may need to be excluded.

When estimating Met values for both the ISWT and the CST this was done by using the levels reached so led to inaccuracy as to the actual Met level attained.

Only two sessions of exercise were supervised making it difficult to measure whether the patient adhered to the third session recommended to them, this may be addressed by using an exercise diary to allow the patient to record exercise performed on another day.

Patients were on different medications including those that blunt the heart rate response and also have fatigue as a side effect. Although all the patients were referred to the cardiac rehabilitation programme they were not matched in terms of their heart conditions and medical problems. The medication that patients were prescribed was not taken into account. If during the trial they
were taken off a medication that affected heart rate their data was removed from the study because this could have altered the study.

As there were only 33 subjects which does not allow extrapolation to the wider population, a larger cohort would be required.

As with all tests of exercise tolerance they are subject to variations in patient motivation and the investigators ability to ensure the patients reach their symptomatic limits.

The study may have benefited from each patient having a definite heart rate end point at which to halt the tests to allow comparison of distance measured/mls/kg plotted to be compared for the same workload. The patients stopped either when they reached their set heart rate or reached a moderately hard/hard workload.

Approximately 80% of the group had undergone revascularisation prior to be enrolled in the programme. Whilst this may reflect clinical practice the results for the group do not necessarily proportionately translate to the constituent groups.

**Recommendations**

Recommendations for future research include using a larger study sample size giving greater statistical power.

It would be useful to be able to use the CST for lower functioning patients; further studies could address this by lowering the height of the lowest step and validating the outcome to allow this patient population to use this valuable resource for measuring exercise capacity.
A comparison of male and female to see if there were any differences between genders may provide useful information as could matching medication, index event and age.