EFFECTS OF PHYSICAL EXERCISE ON THE PERFORMANCE OF THE MENTALLY HANDICAPPED

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Thesis submitted to the University of Adelaide in
fulfilment of the conditions for the
Degree of Master of Arts

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South Australia

1976

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ABSTRACT

The effects of physical exercise on a three choice reaction time task were examined for a group of adults diagnosed as either mentally retarded or psychiatrically disturbed on admission to an Adelaide Vocational Rehabilitation Centre. Results were compared with a group of non handicapped subjects. The reaction time task, which enabled the separate examination of decision time and movement time, was performed on five occasions; once prior to exercise and then after each three minute period of graded physical exercise on a bicycle ergometer. The exercise loads were determined for each individual according to his or her physical work capacity (PWC).

As in previous research findings, the non handicapped population was found to be significantly faster on both performance measures than the retarded group, and in this investigation also faster than the psychiatric group. This result occurred in both the pre-exercise trial and all four post exercise trials. All groups, with the exception of the non handicapped male sample, showed a significant trend to improve in decision time as the demands of the exercise became heavier. However, exercise produced no change in movement time performance in the groups, with the exception of the psychiatrically disturbed female sample, which showed a small initial improvement. Thus these two parameters of reaction time were affected quite differently by increasing amounts of physical exercise. It was argued that the effect of exercise was seen on central decision making processes, rather than on the peripheral areas concerned with such things as arm speed.

The results were examined in relation to the arousal concept and, in particular, the inverted U hypothesis. The absence of the commonly

found inverted U relationship between level of exercise and performance was explained in terms of the duration and intensity of exercise, and the fact that prior rather than concomitant exercise was used. Examination of the data indicated that the effects of exercise did not dissipate over the four or five minute period of the task even though heart rate, the assumed index of arousal, had returned to normal levels.

A second experiment verified that the improvement in reaction time performance was not due to any training effect as a result of repeated exposure to the task.

Physical work capacity (PWC) for the handicapped groups was compared with that obtained from (a) a mentally retarded group from a Rehabilitation Centre in Scandinavia; (b) adult norms available from other countries and a recent investigation in Adelaide; and (c) the non handicapped group used in the study. PWC for the handicapped groups was significantly lower than that reported for their Scandinavian counterparts and for non handicapped subjects overseas. However, when maximum oxygen intake (MvO_2) per kilogram body weight was estimated from PWC, these comparisons between the handicapped and non handicapped groups revealed differences which were far less marked. It was noted that there was a great amount of variability within the handicapped groups on this measure of cardio respiratory fitness.

Recommendations were made on suggested lines of future research, and on possible schemes of physical activity within Rehabilitation Centres.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University, and to the best of my knowledge and belief, the thesis contains no material previously published or written by another person, except where due reference is made in the text.

John A. Halbert

June, 1976.

ACKNOWLEDGEMENTS

I would like to express my gratitude to the management, supervisors and staff of Bedford Industries Vocational Rehabilitation Association Inc., South Australia, for their assistance and co-operation during this investigation. The staff of the Personnel section, in particular Mr. Ivor Snaith and Ms. Gabby Kullack, advised and assisted in the selection of the subjects. I was grateful to have ready access to the personnel records of clients at the Centre. As all subjects had to be tested for IQ, Dr. Ted Nettelbeck provided assistance and guidance in my familiarisation with the test, and monitored several testing sessions to ensure that correct procedures were followed.

Several colleagues at the Adelaide College of Advanced Education assisted in the physical work capacity testing, and offered useful advice and comments about this aspect of the project. In particular, I wish to thank Mr. Richard Roberts for his useful comments on the earlier drafts of the physical fitness sections of this thesis. I also acknowledge my debt to the Adelaide College of Advanced Education for the use of the bicycle ergometers and other pieces of apparatus required in the experiments.

I am grateful to Mr. Robert Willson from the Psychology Department of the University of Adelaide, and Mr. Roger Williams from the Mathematics Department of the Adelaide College of Advanced Education, for their assistance with computer programming and statistical analysis of the data. To Helena Lomax who prepared the figures, I am very grateful. Furthermore, I wish to thank Cynthia Alexander for her excellent typing of this thesis.

Particular thanks must go to my supervisor, Dr. Ted Nettelbeck, whose encouragement, enthusiasm and constructive criticism were of tremendous value throughout the whole project. I have thoroughly enjoyed the experience of working with him. Finally, I have appreciated the patience and understanding of my wife, Chris.

CHAPTER 1

During the last decade there has been a considerable upsurge of interest in the area of recreation for the handicapped, and the view that recreation is a necessary aspect of the life style of handicapped people and an important phase in the total rehabilitation process has met with wide acceptance. If the goal of integrating handicapped people into community recreation programmes is to be realized, then these programmes have to provide for both the learning of recreation skills and the counselling services necessary to provide support for the handicapped. An attempt to stimulate public awareness and education regarding the needs and rights of handicapped persons to participate in community recreation programmes has often been seen as a necessary adjunct to these activities. Recreation schemes have been implemented within associations and rehabilitation centres dealing with the handicapped throughout Australia, and many have claimed some degree of success.

A major component of recreation is concerned with physical activities. Persons responsible for rehabilitative programmes have expressed the opinion that an improvement in the physical fitness and well being of their clients by some means of physical recreation should have a beneficial effect on their work performance. (Calder 1973). Justification for this opinion seems to have been derived largely from the results of "pause gymnastics" programmes in the factories and offices of some businesses in Japan and Scandinavian countries. Pause gymnastics consist of breaks, usually located during the longest working periods of the day, when a series of simple exercises are performed under the direction of a qualified instructor. Usually the exercises are performed to music, are at the work site, and last for five to ten minutes.

One such scheme, which has frequently been used as a model, is still conducted at the Folksam insurance company in Sweden. Although the programme has been in operation since 1960, no extensive scientific investigation has assessed its effectiveness. However, a survey of attitudes among more than 1000 employees indicated that they favoured the scheme. Many involved in sedentary, repetitious jobs and tasks which restricted movement reported that the programme provided "an immediate antidote, right on the job, to the strains and stresses resulting from monotonous, stereotyped working patterns". (Calder 1974 p.35). The prime benefit of the programme mentioned by employees was the mental stimulus it gave, while some reported that it reduced aches and pains. These subjective comments of the employees did seem to indicate that the basic aims of the scheme were being met.

An experimental programme based on the Folksam scheme was introduced in one sheltered workshop in Brisbane during 1973. The programme developed its own particular character to meet the needs of the mentally retarded teenagers and adults who attended the workshop. The results were most encouraging, and the exercise programme became a regular feature of the working day. By careful selection of exercises, adequately supervised by a physical educator, and with a liberal amount of praise and encouragement, it was found that the majority of mentally retarded clients responded well to the programme, attending to the directions and trying hard to perform the exercises. The scheme is reported to be enjoyed by the workers, is not disruptive to their work, and has resulted in the workers being more alert after the break. (Calder 1974). The organisers of this programme have suggested that workers in other workshops would benefit from a similar scheme.

These opinions are of considerable interest to supervisors in vocational rehabilitation centres who are concerned with the well being and life style of their clients, but also recognise the need to improve current work levels. There is an awareness that improvement is necessary if handicapped people are to compete for outside employment opportunities. Unfortunately, to this point, no objective investigations have been conducted to verify the subjective assessments of those involved in the pause gymnastic schemes. It has yet to be shown experimentally that schemes involving physical activity do result in workers being more alert after participation, or that improvement in application to the work and in actual work performance follows physical activity.

CHAPTER 2

2.1 PHYSICAL FITNESS AND ITS MEASUREMENT

Physical fitness has always been a subject which has interested people. It is a term which is used frequently, yet most have great difficulty when asked to describe it in detail. Although people feel that they know so much about it, the term still defies definition, even by authorities who work in the field of human performance.

Davies (1969) has commented that "fitness may be considered as a fundamental qualitative expression of an individual's physical condition". (p.1171). It is usually defined as the capacity to do physical work without undue fatigue, and to recover quickly and completely from the effects of doing the work. This would suggest that the more work a person is able to do the fitter he is. Yet this idea leads to difficulties. Body size must be taken into account, and the speed at which the work is performed, or how long the work is sustained can complicate the assessment of fitness. If skill involves an ability to perform an activity with the maximum degree of certainty and with a minimal expenditure of energy and time, then it follows that the effort required to perform the work will depend on both the activity and the degree to which the person has mastered the task. Observation of an unskilled worker at a task, readily confirms that much more energy is expended in comparison with the skilled performer. It is obvious that activities differ in the degree of skill required to perform them. Thus, it is not simple to define fitness or outline the components which constitute its make-up. "It is highly specific and can only be defined in relation to a given activity". (Davies 1969 p.1171).

Efforts to measure fitness reflect the importance of the factors outlined above. Many so called "fitness tests" have been devised over the years, but most have ultimately been rejected by workers in the field. Differences in methodology have caused difficulties when making comparisons between different tests, and problems of motivating participants have led to the wide rejection of many such measures as tests of physical fitness. Other tests appear as being specific to special gymnastic or athletic skills which are dependent on practice and training. One such battery, the Kraus-Weber test, was used to compare American and European boys and girls. The results indicated that the American children were definitely inferior to the European children on all items with the exception of the softball throw for distance. Apart from this item, all other activities in the test were commonly used in European schools but were not really used in the American system. Thus American children were placed at a considerable disadvantage. Had the other activities been typically American, like the softball throw, then the results may well have been reversed.

This is not to imply that these performance measures are not useful. Astrand (1970) has suggested that they "can be justified from a pedagogic and psychological viewpoint .... to help the teacher or coach to stimulate the athlete's interest in his training." But he adds that "too often the tests are incorrectly claimed to serve a physiological purpose." They may often be unsuitable as tests of physical fitness because they demand "maximal exertion of a subject who may be completely untrained." (p.344). Cumming (1967) has emphasised that, if when measuring the fitness of a population we want to assess their capacity to work, then the determination of maximal strength of various muscle groups cannot be neglected.

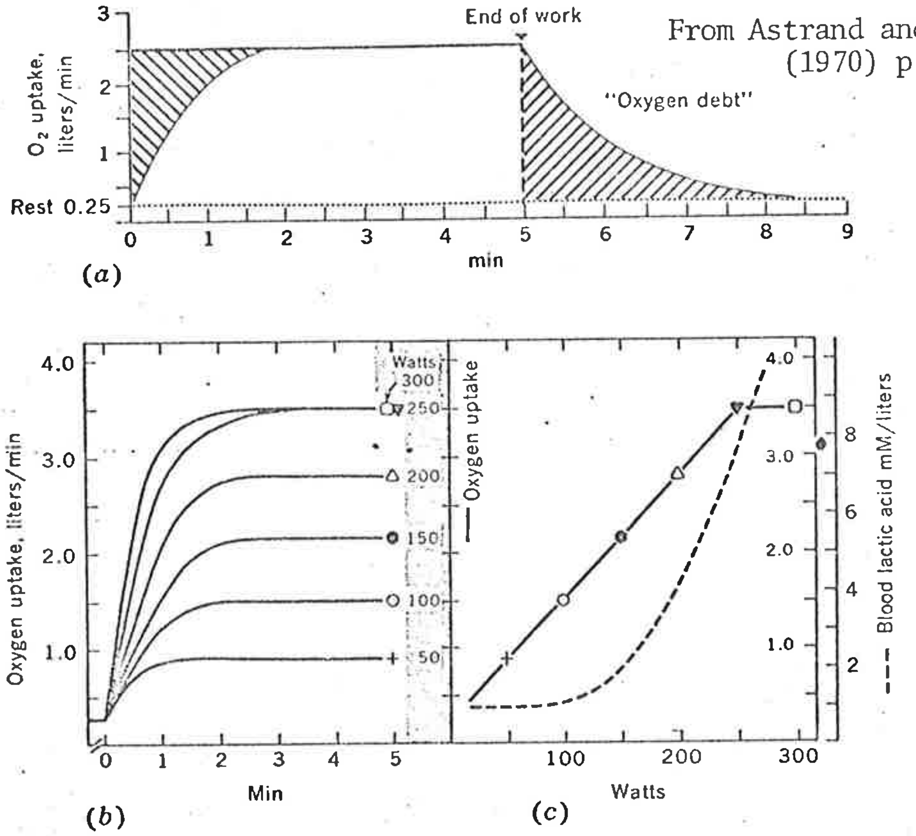
For these reasons most authorities agree that there is no one test of physical fitness. Ideally such a test would involve the measure of maximum aerobic capacity, strength and a few performance items such as a run or a jump. It would examine the major recognised components of physical fitness, namely strength, speed, power and endurance. However, physiological fitness, or the fitness to perform work is the measure which has attracted most attention and popularity in recent years.

Physiological fitness depends on the ability of the person to expend energy, and can be estimated by measuring maximal aerobic power or maximum oxygen intake (MvO_2). Experiments have shown that the higher the oxygen intake, the higher will be the energy output. Despite the complexities associated with the capacity for muscular exercise, it has been estimated that for every litre of oxygen consumed about 5 kilocalories of energy will be delivered. (Astrand and Rodahl 1970) If, as may occur in heavy exercise, the oxygen supply to the working muscles is inadequate for the work which is being done, then a waste product, lactic acid, accumulates in the system. This accumulation is painful, and will cause the person to terminate the exercise or work. Emphasising the distress that this agent of chemical fatigue can cause in athletics, Bannister (1956) suggested that it may well be the performer's ability to tolerate lactic acid accumulation during the final stages of middle distance running events which makes the difference between victory and defeat.

After approximately three to six minutes of work, a steady state is reached where the oxygen intake corresponds to the demands of the tissues for the work being performed. With gradual rises in the workload, a point is ultimately reached where further increases in the load no longer lead to increases in oxygen consumed. This point provides a measure of that person's maximum oxygen intake (MvO_2). Figure 1 illustrates this phenomenon.

FIGURE 1.

From Astrand and Rodahl (1970) p.284.



(a) Illustration of the steady state ultimately gained when oxygen intake rises until it reaches a level adequate to meet the demand of the tissues.

(b) and (c) Illustration of the point of maximum oxygen intake when an increase of work from 250 to 300 watts does not cause any further increase in oxygen intake.

Davies (1969) warned that although MvO_2 "is widely accepted and favoured as a test of endurance fitness .... it only provides limited information on an individual's ability to perform prolonged work." (p.1174). His statement was an attempt to indicate that a person may possess high MvO_2 because of certain genetic factors, yet lack the ability to utilise it because of training deficiencies.

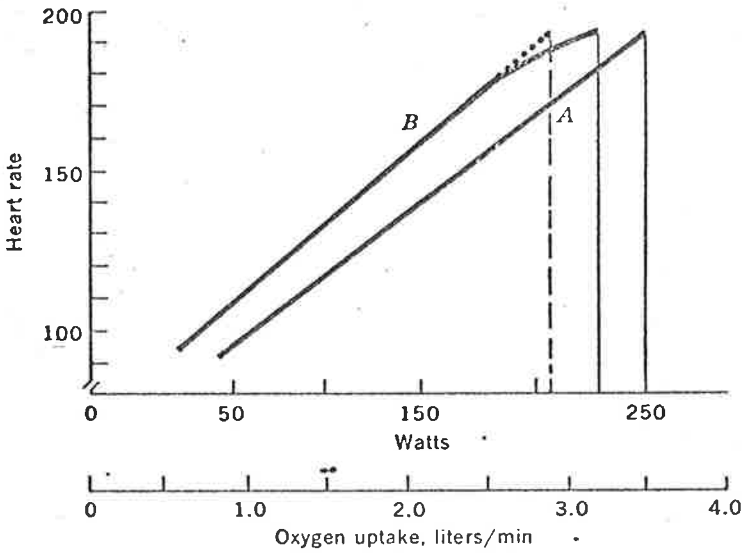
However, while the ability to utilise MvO_2 for varying periods of time, or maximum aerobic capacity, would be a more informative measure of the state of training of an individual, it is not practical at this time because no reliable methods have been developed for its measurement. In the meantime Davies (1969) and other investigators have suggested that MvO_2 is a useful "measure of the potential ability to perfom at high intensity, with large muscle groups for periods of up to about one hour." (p1174).

Three methods have been commonly used to estimate MvO_2. These are the step test in which the subject is required to step up and down on a low bench at a set rhythm; running on a treadmill, which simulates uphill running at a specified speed and slope; and working on a bicycle ergometer, an instrument where both pedal speed and work performed can be accurately determined. The step test has suffered from problems associated with adequate measurement of the work load and difficulties in monitoring physiological responses, and as a result is the method least used in experimental work. Comparable results have been obtained using both the treadmill and the bicycle ergometer, but, because the latter is less expensive and is portable, it has been used more often. (Shephard et al 1968b).

It is now widely accepted that the direct measurement of MvO_2 by the collection of gases during exercise should be regarded as the criterion against which other procedures are judged. However, this procedure does create a number of problems for the researcher. It is time consuming, is a fairly complicated laboratory procedure, and can present problems associated with subject co-operation. Many people are not sufficiently motivated to work to the point of exhaustion required by this test, and it may be quite dangerous to set untrained persons such levels of work.

In response to these problems, several methods of estimating MvO_2 from tests involving submaximal levels of work have been devised. The most popular of these, using the bicycle ergometer, is based on the finding of a linear relationship between increasing heart rate and increasing oxygen intake or work load. (Astrand and Rodahl 1970. p.352). As may be seen from Figure 2 this linear relationship is reliable for the range of heart rate from 120 to 170 beats per minute. The person being tested is required to work at increasing, but submaximal, work loads while heart rate is monitored.

FIGURE 2



The linear relationship between heart rate and oxygen intake or work load for the range of heart rate from 120 to 170. Line B illustrates that for some subjects the oxygen intake may increase relatively more than the heart rate as the work becomes very heavy. MvO_2 may then be underestimated.
From Astrand and Rodahl (1970) p.352.

The linear function determining the relationship between workload and heartrate is then used to obtain the individual's physical work capacity corresponding to a heart rate of 170 beats per minute. This is the highest rate for which the linear relationship with work load remains reliable, and the measurement is termed physical work capacity 170 (PWC170). Maximum oxygen intake (MvO_2) can then be determined by extrapolation using a nomogram constructed by Astrand and Ryhming (1954), and a correction can be made for the individual's weight and age. Figures and tables relevant to this estimation are included in Appendix IA, B, C and D.

Researchers have found that the method of estimating MvO_2 results in an error which varies from approximately 12 percent (Davies 1968) to 15 percent (Weiner and Laurie 1969). As a result, untrained persons are often underestimated and well trained athletes overestimated (Astrand and Rodahl 1970). The error occurs because estimations are dependent upon certain assumptions which are not always valid. Thus, the linear relationship between heart rate and work load, which appears to be valid for heart rates between 120 and 170 beats per minute, certainly does not hold for all subjects. With some, oxygen intake may increase relatively more than heart rate as work load becomes very heavy. Furthermore maximum heart rate varies between individuals and declines with age. Astrand (1960) has introduced a correction factor for age to offset this latter problem. More recently Telford and Price (1973) have further questioned the accuracy of the nomogram as a predictor of MvO_2 in the light of "the recent findings concerning nitrogen which appear to invalidate the open circuit method (Haldane) used in the nomogram's construction" (p.23). Williams (1973) has challenged the assessment of MvO_2 as the best method of estimating cardiorespiratory endurance. He presented data indicating a very low correlation between predicted MvO_2 and the 12 minute run performance, and suggested that "there is growing evidence that endurance performance is a specific ability" (p.27).

Despite these limitations this test must still be regarded as the most comprehensive of the simple tests of cardiorespiratory fitness, and the best available to those who are not experts in the field of exercise physiology. While offering criticism of the technique, Davies (1969) concluded that it remains a decisive measure, and "its measurement in population studies of fitness should be encouraged" (p.1174).

2.2 THE PHYSICAL STATUS OF THE MENTALLY RETARDED

Research among mentally retarded persons has almost invariably indicated that they have lower physical fitness and poorer motor skill development than non-retarded people (Bruininks 1974). Hayden (1974) reported that almost every investigator has found generally lower levels of fitness among retarded children. The one notable exception has been the work of Cumming and his associates (1971) who found higher working capacities among retarded subjects. The fact that Cumming et al used physical work capacity as the index may explain this unusual finding.

Studies by Francis and Rarick (1959), Howe (1959), and Rarick, Widdop and Broadhead (1970) all found that, although retarded children followed approximately the same developmental pattern as normal children on the tests used, they were consistently inferior on measures of physical fitness. Deficits ranged from about two to four years and increased with age. Several other interesting findings also emerged from these studies. Boys scored one standard deviation below the mean of their non-retarded peers, while girls were one and a half standard deviations below their counterparts. Measured intelligence among retarded subjects was generally found to correlate with physical fitness, and, as the tasks in the tests gradually increased in the complexity of co-ordination required, so the difference between the retarded and non-retarded samples increased.

There are, however, several other comments which should be made about these studies. In all of them a wide range of scores was obtained for the physical fitness of both the retarded and the non-retarded samples, suggesting considerable overlap between the two populations. On some occasions, national norms have been used for comparison with the retarded samples, a practice which neglects possible experiential differences in motor activities. The major portion of the documented research has used samples of children, or young adults up to the age of about twenty, and very little work has been carried out with older adults. In addition, the fitness measures most frequently used in these studies have been either the youth fitness test (A.A.H.P.E.R. 1965), or derivations based on that approach. As mentioned earlier, many such tests have now been rejected on the grounds that they measure specific athletic performances rather than basic physiological functions.

Very few studies have been reported in which the physical fitness of a mentally retarded sample has been assessed by the calculation of their physical work capacity using the bicycle ergometer. Bäcklund and Nordgren (1969) tested a group of 25 retarded rehabilitees in a Swedish centre, and found that their physical work capacity (PWC170) was lower than normal. However, the level for women was no lower than some other female rehabilitation groups. Nordgren (1970) supported this study with a more extensive investigation, involving 63 rehabilitees. He reported that "the mean value obtained for physical work capacity (PWC170) did not deviate essentially from those of the normal scores, either for men or women." (p.130). However, he did find considerable individual variation in capacity, particularly among the men, and, as 16 subjects were rejected from his sample because of their inability to satisfactorily complete the bicycle ergometer test, this outcome must be viewed with caution. It seems likely that the 16 rejected subjects would have had a lower PWC170 than those who completed the test. Thus, although the mean value recorded for the group was near normal, the results may not have reflected the physical fitness of the total retarded population.

A similar pattern emerges when attention is turned to the motor skill of retarded persons. A considerable body of evidence suggests that mentally retarded youngsters are less able than non-retarded counterparts in almost any type of physical skill, and that discrepancies in the normal developmental sequence increase with age. Research in the areas of both gross and fine motor skills among the retarded support these conclusions, and indicate that it is probably in the area of simple balance skills that the discrepancy is least marked, and in the area of bilateral co-ordination and equilibrium balance that it is greatest. Calder (1972) has emphasised that acceptance of these concepts can lead to over simplification and erroneous assumptions. She illustrated the point by comparing a child who walks at 15 months with a mentally retarded child who does not walk until the age of five years. By this later age, the retarded child has the physical development to cope with activities far in advance of the basic walking skill, but, because the child has not walked at an earlier age, many skills with the prerequisite of walking will not have been mastered. Thus the child will probably evidence a "lower fitness level, weaker muscles, less motor skill and less ability to cope with his physical environment than is needed" (Calder 1972. p.18). Yet, despite the problems associated with over generalisations and the obvious shortcomings which have been exposed in regard to the tools of measurement used, the evidence is quite conclusive that the mentally retarded are poorer in motor skills when compared with the normal population.

Many reasons have been offered in answer to these findings. Hayden (1974) suggested that "it seems quite natural to accept the awkward and clumsy movements so apparent in many of the retarded as automatic side effects of mental deficiency" (p.217). However, most investigators now agree that environmental factors play a far more important role than was previously realised. This is not to deny the possible influence of intellectual level on such factors as motivation and curiosity, and hence the manipulative level and skill of the individual. But as Hayden (1974) went on to state "comparison of the typical daily regimens of retarded children and their non-retarded counterparts suggests quite strongly that restriction of physical activity, rather than something inherent in their retardation, may be the major cause of their physical inadequacies." (p.218).

Not only are most of the physical activities unsuitable for retarded individuals, but also, because they are poorer learners, they require far more direct instruction and supervision than is normally given. Over protective parents and the need for close supervision certainly limit the range of play opportunities available to these children. These factors then compound the situation as the retarded child has difficulty in playing with other children and may ultimately be rejected by his peers. Community reaction to retardation may further exacerbate the effects of this rejection. Nordgren (1970) found evidence of this in his study of an adult sample of mentally retarded rehabilitees. Many reported that previous attendance at school and participation in gymnastics and sport had been very unsatisfactory. Abnormal appearance as well as behavioural patterns often resulted in teasing by the other pupils; a number in his sample reported a direct aversion to any form of physical training.

The important question has often been asked as to "how much of this motor retardation is really inescapable for a specific individual, and how much is the product of a sedentary life style that starts early in childhood and progresses throughout the life of most retarded persons?" (Hayden 1974. p.217). Results from programmes of physical activity have indicated that the problem with the physical status of the retarded can be rectified, at least in part. Nordgren (1970) reported a considerable increase in the circulatory capacity of his group of rehabilitees after a period of physical training. In a study of 14 year old boys, a four month training programme resulted in an increase in MvO_2 of 14 millilitres per kilogram body weight from the rather poor level of 34 millilitres to 48 millilitres (Thoren 1971). Thoren also claimed a number of beneficial psychological effects, and suggested that the physical training played an important part in the general social adjustment of these children. Numerous studies investigating the effects of programmes of physical education on physical fitness, using measures other than MvO_2 have suggested similar dramatic improvements (Calder 1972).

One of the earliest, controlled studies on the effects of physical education in the area of retardation was conducted by Oliver (1958). His ten week intensive programme resulted in "significant improvement .... in athletic achievement, physical fitness and strength". (p.159). There were measurable and significant changes in emotional stability, medical evaluation and personality adjustment. He also reported that more than 25 percent of the boys in the sample achieved increases of more than five points on the Binet test of IQ. Finally, Oliver reported marked improvements in motivation, co-operation, self confidence and perseverance which he believed contributed to the changes seen in the group. Corder (1966) replicated this experiment with controls for the possible beneficial results of better morale arising from the attention and interest shown the subjects by the experimenter. He found similar gains in the development of gross motor abilities and in IQ among the boys in his sample, but not among the girls. Ismail and Gruber (1967) conducted a one year organised programme of physical education with children of high, medium and low intelligence, and reported no effect on IQ scores, but significant advances on mean academic achievement scores. There are many other studies, with slightly different orientations, which have supported findings similar to those reported by these experimenters. (Calder 1972).

One of the few studies using an adult mentally retarded sample was done by Leighton and his associates (1966). They conducted a programme aimed at raising the physical fitness level of ten retarded males in a vocational setting. Results indicated a rise in physical fitness scores as measured by tests of strength and endurance, a positive increase in self concept (how subjects viewed themselves), and a positive shift in mental age ratings. Evidence of job proficiency was only available for one subject, but he showed an increased rate of productivity on his job.

The potential of physical activities for improving the physical condition and physical performance of the retarded has been clearly identified. Bruininks (1974) drew attention to the persistent methodological problems of poor sampling strategies, the restricted range of instruments to assess motor proficiency, and the common tendency to ignore motivational and conceptual factors in assessing motor proficiency. Yet he has confidently asserted that with sustained effort and improved methodology, more definitive findings will emerge to support these programmes. It is possible that better physical education programmes may influence a great many secondary, non-physical characteristics. Stein (1966) stated that "undoubtedly the progress that has been shown by mentally retarded subjects who have participated in planned programmes of physical education, has accrued through the interplay of a complex of factors: achievement and success (for many it may be the first time they experience the satisfaction of even completing a task), improved confidence, better adjustment, a feeling of importance because of the interest and attention centred on them, increased competitive spirit, increased pride, improved physical condition, more perseverance and increased desire to perform well." (p.27).

2.3 THE PHYSICAL STATUS OF THE MENTALLY DISTURBED

As was the case with the mentally retarded population, studies investigating physical fitness among mentally disturbed persons have revealed depressed levels in comparison with the normal population. This area has not received a great deal of attention, although, during the past decade, increasing interest has been directed toward exploring any relationship which may exist between the presence of mental illness and the level of physical fitness. Dodson and Mullens (1969) recognised that much of this interest has arisen because of problems facing these patients when they are attempting to re-enter the community. Many fail to make the transition not only because of psychological factors, but also because of an inability to cope with physical demands; particularly in the work situation. While rehabilitation programmes have sought to motivate them to return to the community, they have seldom attempted to prepare these people physically for the situations into which they will go.

Two studies of mental hospital patients with chronic disorders (Carlsson et al 1965, 1968a) found that physical work capacity was often low. All subjects used in the second investigation had a low physical work capacity on the bicycle ergometer, and most had a reduced volume of blood pumped by the heart for each stroke(stroke volume)in relation to the overall heart volume. Hodgdon and Reimer (1960) administered a fitness battery including six tests of muscular performance and a test of lung capacity to 42 male schizophrenic patients. The scores from the battery of tests enabled a physical fitness index to be calculated. The group of patients had a mean physical fitness index of 70.6 percent when compared with the non-handicapped norms associated with this test battery. These findings appear typical of studies which have investigated the physical fitness of mentally ill populations.

A number of explanations have been offered for this situation. It could be that the reduced physical performance is a direct outcome of the mental disease itself, although there appears to be little evidence to support this hypothesis. Alternatively Dencker (1971) has suggested that the lack of communication, general passive nature, and distinct tendency to regression and autistic thinking, which characterise many psychotic patients are likely to lead to less and less exercise, and thus a reduction in muscular strength and physical work capacity. Dencker also suggested that the mentally ill may offer resistance to physical activity because of the anxiety associated with some of the physical symptoms of exercise such as lack of breath and a pounding heart. Imagined damaging effects of exercise may cause anxiety, and lead to patients actively avoiding any physical activity. He referred to this as "active inactivity". Finally, the side effects of psychopharmacological treatment may have some influence on the depressed levels of physical performance. Such side effects as fatigue and circulatory disturbances from the use of antipsychotic drugs have been found in several studies. (Carlsson et al 1968 (a) and (b)).

Programmes of systematic physical activity have been shown to contribute to improvement in the status of persons with psychiatric disorders. Carlsson et al (1968b) subjected nine schizophrenics to an extensive programme of physical training, consisting of three 6 minute periods of strenuous exercise on the bicycle ergometer five times a week for periods up to four months. Following the training programme, they reported an improved physical performance on the bicycle ergometer for all but two of the patients, and improvement to normal levels in a number of physiological measures which were at a low level prior to the scheme. They concluded that physical training can be carried out successfully with mentally ill persons who have been inactive, although they added that certain medications may limit the beneficial effects on the circulatory system.

Dodson and Mullens (1969) established a jogging programme for selected subjects at a psychiatric hospital. The programme was extended over a three week period, and involved jogging over a mile course five times a week at the subject's own rate. The patients were tested on a variety of physiological and psychological measures both prior to commencement, and at the conclusion of the jogging programme. Results of the physiological tests revealed a trend in the expected direction of increased physical fitness, although only a few measures reached acceptable levels of statistical significance. The findings on the psychological measures were far more difficult to interpret, but the authors concluded that the effects were favourable ones. They also observed that only ten of the 18 patients were still in the hospital six months later, but were quick to admit that this may have been caused by a "halo effect", or more positive attitudes for these patients, rather than a direct outcome of the jogging programme itself.

Dencker (1971) suggested that a programme of physical activity should be a necessary compliment to other psychiatric treatments. Not only did it get the mentally ill out of the vicious circle where autistic thinking and hypochrondria dominate, but it provided a very useful step in the process of vocational rehabilitation, which presents many difficulties for the chronic patient. He concluded by suggesting that, although the effects of hard physical activity appear to be of short duration, "much should be gained from a well-being point of view, if specific anti-depressive therapy could be combined with a properly balanced physical training programme" (p.58).

Despite the volume of research which has been conducted using mentally retarded and psychiatric persons, little assessment has been made of the effects of physical activity programmes on the level of arousal among handicapped people. There is considerable evidence for the facilitating effects of exercise on the level of arousal in non-handicapped groups. (Gutin 1973b). Similar measures among handicapped groups would aid in the evaluation of the effectiveness of planned programmes of physical training or recreation.

CHAPTER 3

3.1 HISTORY OF THE AROUSAL CONCEPT

The concept of arousal has interested researchers during both the nineteenth and twentieth centuries. Early workers involved in the study of motivation and emotion placed considerable importance on the part which arousal was presumed to play in the explanation of physiological aspects of these constructs. The early work of Cannon (1929) suggested the presence of a number of autonomic reactions which prepare the person for an emergency. Further research led to the basically similar propositions of Hebb (1955) and Malmo (1959), who hypothesised that the higher centres of the brain were made more sensitive and responsive by streams of impulses from a suggested arousal area within the brain stem. Welford (1965) further suggested that, under conditions of arousal, cortical cells were depolarised by impulses, thus making them more likely to fire than they would normally. More recently the concept of arousal has been applied as a possible explanation in a variety of theories ranging from a theory of aggression and frustration (Berkowitz 1969), to an arousal seeking theory of play (Ellis 1973).

3.2 MODELS OF AROUSAL

A diversity of meaning has been attributed to the basic construct of arousal, but the ideas proposed by Duffy (1962) appear to have been widely accepted. Yet even Duffy's own more recent views have varied from her earlier propositions. Since 1962, she has not distinguished between the terms "activation" and "arousal", and has defined the concept as being "the extent of release of potential energy, stored in the tissues of the organism, as this is shown in activity or response." (Duffy 1962, p.17). Arousal has been seen as a continuum, ranging from deep sleep at one pole, to extreme excitement at the other. She has considered arousal as the intensity dimension of behaviour, which, when linked with the other basic behavioural dimension of direction, would indicate a person's motivation.

Yet there are some investigators who do not accept the position adopted by Duffy. Fiske and Maddi (1961) did distinguish between activation and arousal, by confining the former term to the degree of excitation of a brain centre, and the latter to explain the peripheral results of the activation. Whereas Duffy has considered arousal to occur along a simple continuum, other authorities have regarded this view as too simplistic, and suggested that it is more useful to think of several systems or forms of arousal. Lacey (1967) has argued for three forms of arousal; the electrical activity of the cortex, activity under the control of the autonomic nervous system and behavioural arousal. He observed that it was unlikely that a useful distinction could be drawn between direction and intensity in behaviour, because they are interrelated in the ultimate action. He proposed that it would be more profitable to study the patterns of responses to a variety of stimuli.

Examination of the effects on performance of a variety of stimuli, which have been suggested as causing changes in arousal level, have revealed a rather complex picture. While performance improved with increasing arousal up to a certain point, more intense degrees of arousal caused a deterioration in performance. There appeared to be a maximum level of arousal, above and below which, performance was less than optimum. Thus the relationship between arousal and performance has often been reported as curvilinear, and to take the form of an inverted U with the peak of performance when activation was at a moderate level. The original hypothesis of Hebb (1955) and Malmo (1959) provided an explanation for the improvement in performance with moderate levels of arousal. However, the reason for the decline in performance with increased arousal was not as clear. Welford (1965) suggested that as diffuse impulses became more intense, the cortical cells not only became more sensitive, but actually began to fire spontaneously. This made the brain "noisy", and reduced the information processing capacity of the brain by occupying cells which would normally be available to carry signals. Cooper (1973) preferred to explain the decline in terms of the involvement of neurons "in the fringe". These were thought to be neurons where either their synaptic contributions or level of excitation were such that summation was inadequate. With increasing arousal, some of these would be activated and would produce "noise" in the system. He proposed that this could either disrupt the neural patterns, or lower the thresholds of competing patterns which might then dominate the original sequence. On this basis it appeared that the inverted U hypothesis was the most appropriate model to explain the relationship between arousal level and performance.

The inverted U hypothesis, derived from the Yerkes-Dodson Law, was not the only hypothesis suggested. Spence and Spence (1966) have advocated a drive theory hypothesis. In this approach, arousal and drive were seen as synonymous when the latter was regarded as being non-specific and non-directional. Drive theory predictions, however, were not as clear as those of the inverted U hypothesis. A positive linear relationship was predicted when the correct response was dominant, but the predictions were not as clear when the dominant response was the incorrect one.

Martens (1971, 1972) reviewed the experimental evidence testing the drive theory, where both trait anxiety scales and stress stimuli were used, and found no consistent pattern emerging from the studies. In a subsequent review article in 1974, he observed the common dilemma that failure to verify, either by physiological measures or subjective reports, that changes in the level of arousal had occurred, left him uncertain whether any such changes had actually occurred in the experiments. He stated, "in concluding the review of the literature examining the relationship between arousal and motor behaviour using drive theory and its extensions, unfortunately, it can only be stated that the evidence is ambiguous at best". (p.173).

It appears then that drive theory did not enable any clearer understanding of motor behaviour to emerge. When Catalano (1967) considered the results of his experiment investigating the effects of auditory stimulation on the prevention of performance decrement on rotary-pursuit tracking, he concluded that the concept of arousal provided a more satisfactory explanation than drive theory with its attachment of inhibition and its dissipation. While drive theory continues to provide ambiguous results and fails in its extension because of limited task specifications, it must remain inadequate as a model to explain the relationship between arousal and motor performance.

Thus the inverted U model, which has received considerable empirical support, has been widely accepted as the more satisfactory model. In fact as Martens (1974) observed, the inverted U model has occurred with sufficient regularity to cause drive theorists to modify Hullian notions, in an effort to explain the findings. He further postulated, that "the inverted U hypothesis tends to supercede the drive theory hypothesis". (p.182). This is feasible because, with imprecise measures of arousal levels, any positive linear relationship obtained could be explained in terms of insufficient intensity of arousal to cause a decrement in performance. In other words, only the ascending section of the inverted U was under scrutiny in that particular study. In many of the studies investigating arousal effects on performance, this has certainly been the case, and the assumption is therefore not unwarranted.

Apart from the unsatisfactory attempt by drive theorists, several other theories have been proposed to explain the inverted U hypothesis. Welford (1973) has suggested that signal detection theory within the field of psychophysics can account well for the inverted U relationship between the level of arousal and performance. It may well be the best hope in improving measurement of points along the arousal continuum, provided that future studies are reported in greater detail. Weingarten (1973) used Easterbrook's (1959) attentional theory to explain the U shaped relationship. This theory proposed that arousal affected the range of cue utilisation by gradually eliminating irrelevant cues up to the optimum performance level, but then caused relevant cues to be overlooked once arousal became too high.

Despite the controversy which surrounds the concept of arousal, it is still widely regarded as having considerable worth. Berlyne (1967) described it as an intervening variable which could be best defined by examining its antecedent and consequent variables. He further suggested that, because many of the consequent variables were imperfect as measures due to the influence of factors other than arousal, it was little wonder that these variables were poorly correlated with each other. It may well be then that arousal, which has in the past been used largely as a "post hoc" explanation of behaviour, will continue to be a theory with poor definition, and yet a construct of considerable worth when incorporated in other theories.

3.3 INDICES OF AROUSAL

Some attempts have been made to examine the physiological bases which underlie the concept of arousal. Cooper (1973) reviewed the available literature in the area, and concluded that, while accepting many of the explanations which implicate the influence of the reticular formation, "the matter is not as readily established, physiologically, as one could hope." "It is not even entirely clear what one should be looking for." (p.601). On the one hand he cited evidence in support of the structural unity of the reticular formation as a matrix of similar neurons stretching from the spinal cord to the cranial end of the brain stem, and, on the other, evidence suggesting some localisation of function. He believed that it was not possible at the present time to reconcile the findings of these two lines of research, and that the physiological bases of arousal must remain uncertain at this point of time.

Work examining the effects of changes in the level of arousal on performance has been marked by equivocal findings. In numerous studies, negative results have cast doubts whether performance has, in fact, been influenced or not by changes in arousal, or whether there has really been any effective change in the arousal level. The reluctance of some experimenters to attempt to find indices of proposed changes in arousal level has, to a large degree, created this confusion.

However, some attempts have been made to find an adequate index of this underlying hypothetical construct. The many diffuse manifestations of arousal have made it very difficult to obtain a consistent, valid and reliable index. Some of the indices considered have involved such parameters as the electrical activity in the cortex, and a variety of autonomic functions. The former is measured by the electroencephalograph (E.E.G.) which indicates the brain rhythm. The E.E.G. can be readily described in terms of its frequency, amplitude, location and responsiveness to stimuli. Researchers have classified the various types of electrical potentials into wave types, and have sought to equate the wave types with different levels of activation or arousal.

A variety of physiological parameters, under the control of the autonomic nervous system, have also been used. Walter Fenz, in association with several investigators, has applied some of these indices in studies of arousal. Fenz and Epstein (1967) reported a study involving the investigation of gradients of physiological arousal in both experienced and novice parachutists leading up to and following a jump. They recorded skin conductance, heart rate and respiration rate at various stages of the exercise. All three physiological measures taken were found to be positively correlated with each other, and the authors suggested that they may well be integrated into a common system of arousal. Yet they also observed that, while intra subject correlations were relatively high under normal levels of stress, they were low when the situation was very stressful. This suggested at least some degree of independence among the different body systems measured. In experiments using the same indices, Fenz and Graig (1972) and Malmo (1959) found reasonable correlation between the measures of palmar conductance, heart rate and respiration rate. Malmo (1959) also found that correlations within any single physiological measure were even more concordant.

While these studies appeared to suggest reasonable correlation between the indices of arousal, there is some evidence to the contrary. Both Sheer (1957) and Stennett (1957) emphasised that E.E.G. and skin conductance were not positively correlated, for, while conductance apparently increased gradually as supposed arousal increased, E.E.G. rose steadily to an asymptote, and then fell again to a low level. Martin (1961) also found low inter-correlations among the physiological measures of arousal.

The great diversity of opinion regarding the arousal construct has made arousal difficult to measure, and has subsequently placed limitations on the usefulness of the concept. It is therefore not possible at this stage of the development of the concept, to assess accurately the point on the arousal continuum at which a person may be at any point in time. Only crude indicators of increases or decreases in arousal can be used. As a result of this, although a few subjective questionnaires have been used in arousal, changes in arousal level have usually been assumed on the basis of overt changes in behaviour, or simple subjective reports from the person concerned. Certainly then, heart rate, which is the easiest of the physiological indices to record, and appears to be as reliable an index as is presently available, should be used more frequently as an indicator of increases and decreases in arousal.

3.4 PHYSICAL ACTIVITY AND AROUSAL

Many stimuli have been suggested as responsible for the general activation of the brain and autonomic nervous system. Noise, electric shock, drugs, heat, fear, anxiety and emotionally charged situations have all been shown to affect some measure of behaviour, by a suggested change in arousal level. More recently, physical activity or exercise has commanded considerable interest as another important cause of activation. Cooper (1973), in support of the arousal effects of exercise, suggested that "the greater activity in this system could arise, on the one hand, as a part of the central programme initiating the muscular activation and associated cardiovascular excitation; and on the other, as a result of afferent feedback from these peripheral changes." (p.601).

Experimenters have used various forms of physical activity to achieve changes in the level of arousal. It is not very surprising that these forms have been confined to physical activities which can be carried out in the laboratory, and to forms where the amount of work being achieved can be measured with some degree of accuracy. The most commonly used laboratory ergometers, the bicycle and the treadmill, meet these two requirements, as they enable a person to do physical work at a prescribed work load while under the constant attention of the experimenter. They have the added advantage that the experimenter can monitor certain physiological measures, such as heart rate, respiration rate and skin temperature while the person is working. Heart rate may provide an indicator of the arousal level, and since there is a linear relationship between heart rate and the amount of physical work done for the heart rate range from 120 to 170 beats per minute, the work load chosen can also provide a reasonable indicator of the arousal level. (Astrand and Rodahl 1970).

The ergometer also provides the experimenter with the option of examining the criterion task, either while the person is performing the work load or immediately afterward; i.e. it is possible for the subject to perform the task while exercising, or to do the task immediately after the work phase has ended. The other type of physical activity, which has been commonly used as a method of changing the level of arousal, is step ups or stool stepping. The subject is required to step up and down on a bench of a prescribed height, at a certain rate, usually maintained by a tape recording. This is less sophisticated and precise than the laboratory ergometers, but involves less expensive equipment, is better suited to field experiments, and still allows reasonably accurate estimations of work load.

3.5 PHYSICAL ACTIVITY AND MENTAL TASKS

A number of investigators have examined the effects of increased activity on a variety of mental functions. Davey (1973) investigated the relationship using the bicycle ergometer for the exercise levels, and the Brown and Poulton (1961) test of attention as a readily quantifiable test of mental performance. His results indicated a definite facilitating effect of exercise on the performance of the attention task. In a follow up experiment, subjects were allocated to one of five treatments, which varied in the amount of work required on the bicycle ergometer. The mental task remained the same. An inverted U relationship between the physical activity and the subsequent mental performance was obtained in line with the commonly accepted hypothesis. Those subjects on moderate levels of work performed significantly better than those at severe exercise levels, where performance was very poor in comparison. Although the extremes of the inverted U relationship indicated clear cut findings, the area of optimum performance was far less distinct.

Davey's results indicated that "the point at which facilitation gave way to impairment would be likely to vary somewhat between individuals." (p.598).

In a subsequent experiment of similar design, Davey (1974) found that short term memory performance, as measured by the Weschler digit span test (Wechsler 1955), remained relatively constant at lower levels of physical exercise, but deteriorated quite rapidly as the exercise approached the person's maximum capacity. Results on the Poulton test of attention mirrored closely Davey's earlier findings, and in addition, he found that extraverts could withstand more physical activity than introverts before attention performance was adversely affected. This finding supported his previous conclusion that the area of optimum performance could be expected to vary between individuals.

In a similar experiment to that of Davey, Gupta (1974) used periods of two to fifteen minutes of step ups, and mental work consisting of simple sums of one digit on addition, subtraction, multiplication and division. Periods of two through to ten minutes of physical activity resulted in an improvement in the mental performance, while exercise periods in excess of ten minutes resulted in a decrement in the task. Unfortunately, he did not examine his results in relation to any model or theory of arousal, but rather proposed that the decline at excessive levels of exercise was caused by a lack of oxygen available to the cerebral cortex, which resulted in a loss of function in higher level cognitive processes. He did not offer any physiological evidence to support his proposal.

Kronby (1974), in an unpublished thesis summary, reported interesting effects of exercise on certain mental abilities in young boys. He found that performance on mental tasks deteriorated when the exercise on the bicycle at 600 kilopond metres per minute was carried out simultaneously. Performance on a number of tasks including a mathematical, a perceptual and a manual test appeared to be best when the persons were working at a low physical work rate, and deteriorated when the load approached the maximum rate of which they were capable. He suggested that it was desirable for an individual to maintain a low working heart rate either by some low level of physical work or by acquiring a good state of physical fitness. He added that "a person's psychical ability to perform could be raised indirectly through improving his state of physical fitness." (p.27). Kronby also proposed that the optimum level of performance should exist at the heart rate reached for the normal level at which the person most often works. However, such a proposition is rather vague, and will be challenged by some of the empirical findings which are to follow.

Several studies have considered the situation where mental tasks were performed during the actual period of physical exertion. Dornic et al (1973) found that eight minutes of bicycle riding at 300 kilopond metres per minute, at a heart rate of 98 beats per minute, improved recall on a short term memory task, by increasing the proportion of correct responses and decreasing the time required to produce a response.

Some of the findings of Stockfelt (1970, 1973) are interesting in relation to the results and propositions of Kronby (1974). In one such study, (1970), he found that performance of a physiologically well trained group on arithmetical computations, while riding a bicycle at various percentages of their MvO_2, was superior to the poorly trained group. It was only at 45% of their maximum that all groups performed similarly. While the mental performance of the "fit" group deteriorated at a work load of 85% of their maximum, this level was still considerably higher than the other group who began to deteriorate at about 65% of the MvO_2. These results add credence to the suggestion of Kronby that improvement in physical fitness should lead to improvement in mental performance, and also suggest that concomitant exercise does not necessarily interfere with mental tasks.

Two separate experiments by Weingarten (1973) confirmed these results; he found that a group of subjects, classified as fitter on the basis of MvO_2 testing, also scored significantly better than their less physically fit counterparts on a test of abstract reasoning during strenuous exercise. In the second of these studies, a similar result was achieved after the experimental group had undergone a fitness programme for seven weeks. It was significant that performance on the reasoning task, during the strenuous exercise on the treadmill, remained relatively constant for the fit group, but deteriorated significantly for the less fit group, when compared with performance in the absence of severe exertion.

Gutin (1973b), who referred to the effects of exercise as "exercise induced activation" (E.I.A.), reviewed most of the studies where exercise was used concurrently with numerical tasks, and concluded that there was no consistent body of evidence to indicate that performance was improved by the arousal effects of exercise. He did concede that "it was unclear whether numerical task performance drops off linearly with concomitant exercise." (p.263). In contrast, experiments reviewed earlier, (Davey (1973), Gupta (1974)), where exercise was used prior to the intellectual task, consistently returned inverted U relationships. It may well be that concurrent exercise interferes with mental tasks or distracts the person by competing for his attention, while prior exercise increases arousal by raising the heart rate to a level of about 120 beats per minute, which may facilitate intellectual functions.

3.6 PHYSICAL ACTIVITY AND MOTOR SKILLS

Considerable interest has centred on the effect of physical activity on the learning and performance of motor skills. However, the outcome of research to date is ambiguous and no consistent pattern emerges. Proponents of drive theory have predicted that early increases in arousal would impair performance when incorrect responses were dominant, but facilitate performance later in the process when correct responses became dominant. However, Ryan (1961) and several other researchers found no effects on performance, regardless of whether the arousal producing stimuli occurred early or late in the process.

The effect of arousal producing stimuli on the learning of motor tasks is even more difficult to determine. If activation can be shown to increase the possibility of more correct responses being made, then it should improve learning. Unfortunately many of the studies investigating the effects of arousal producing stimuli on learning have lacked an independent index of arousal, making interpretation of results difficult.

Using electric shock to increase arousal, which was assumed to be a correlate of anxiety, Sage and Bennett (1973) found that contrary to predictions, both performance and learning on a pursuit rotor task were enhanced by shock. Two other interesting findings from their research were the facilitating effect of the shock on reminiscence, and the observation that stimulation did not always result in the high arousal level anticipated. In a similar experiment, Marteniuk (1969), although essentially interested in the directional aspects of the arousal concept, obtained results which indicated an improvement in performance as a result of arousal assumed to be induced by shock. Certainly, further research is needed to clarify the findings in this area.

When a study is made of the relationship between physical activity and motor performance, there is a huge volume of research which borders on the subject, but which is difficult to interpret because of certain methodological difficulties. Gutin (1973a, 1973b) reviewed a great many studies concerned with the effects of "exercise induced activation" (E.I.A.) on a variety of motor tasks, but was unable to present any clear picture of the possible relationship. Many experiments have made comparisons only between very high and very low or even resting levels of arousal, and have therefore not been able to offer any suggestions about the arousal level for optimum performance on that particular motor task. Typically if performance was found to be low after relatively strenuous exercise, then the exercise has been reported as fatiguing, while if it influenced performance favourably it has been considered to be a kind of 'warm up'. A number of studies have used forms of exercise localised to certain muscle areas. These may not have had the effect of increasing general activation.

A few studies have attempted to determine whether, in fact, a curvilinear relationship between arousal and performance does exist, by examining the effects of varying intensities of exercise on certain motor performances. Gutin (1973a) summarised an unpublished doctoral dissertation by Babin (1966), in which subjects pedalled a bicycle ergometer at specified workloads with either arms or legs for period of 3, 4, 5, 6 or 7 minutes, and then performed a simple reaction time task. The results took the form of an inverted U, with reaction time improving after 3, 4 and 5 minute workloads, remaining similar to pre-exercise for the 6 minute load and deteriorating significantly after the 7 minute workload. Sjoberg (1968) also conducted a reaction time experiment, using varying levels of exercise. Subjects performed a dual choice reaction time task while pedalling a bicycle ergometer at 150, 300, 450, 600 and 750 kilopond metres per minute for periods of over five and one half minutes. Heart rates recorded at these workloads ranged from 84 beats per minute to 147 beats per minute. Results again indicated an inverted U relationship with optimum performance on the reaction time task at the workload of 450 when the average heart rate was 121 beats per minute.

Levitt and Gutin (1971) followed up this study with two experiments of similar design, using exercise on a treadmill and a motor task involving five choice reaction time and movement time. Rather than have all subjects work at the same loads with no allowance for differing levels of physical fitness, the workloads were adjusted so that subjects reached heart rates of 80, 115, 145 and 175 beats per minute. Subjects performed the task while walking on the treadmill after their heart rate had reached the specified level, and had remained constant at that level. Again a curvilinear relationship was found between exercise and five choice reaction time, with optimum performance at 115 beats per minute and poorest performance at 175 beats per minute. A positive linear relationship was found between exercise and movement time.

In the second of these experiments, the motor task was expanded to include both simple reaction time and two choice reaction time, and the experiment was extended over several days to overcome any cumulative effect of arousal which may have contaminated the results of the first experiment. The results indicated no significant interaction between exercise and the type of reaction time task, but again revealed that performance was superior at heart rates of 115 and 145, and poorest at the resting level of 80 and at 175.

The factor which has consistently limited the interpretation of results from studies investigating the relationship between physical activity and motor performance has been the nature of the motor task. The Yerkes-Dodson Law (1908) states that difficult tasks are performed better under conditions of low arousal level, and easy tasks under conditions of higher arousal level. Investigators like Hammerton and Tickner (1968), Martens (1974) and others have talked about task difficulty, but have failed to define how this degree of difficulty might be determined. Oxendine (1970) suggested three broad categories into which tasks could be divided, but, although his proposal has face validity, more precise knowledge would be necessary for their application to be of any practical value. Some scheme or classification system, which clarified the nature of the motor task, would certainly assist the interpretation of empirical findings.

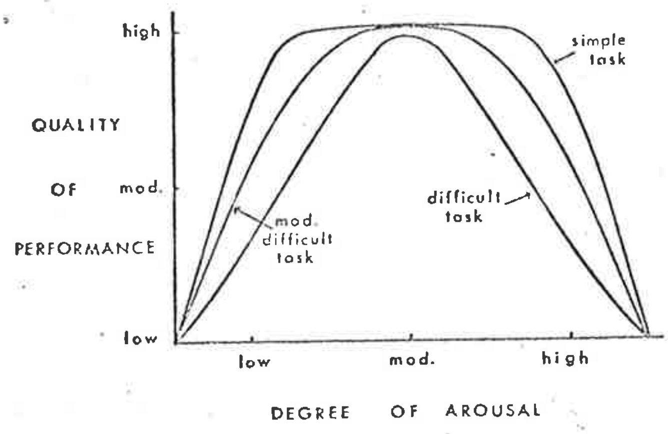
Gutin (1973b) has proposed that motor skills might be arranged along a continuum, based on the degree of inhibition of irrelevant central activity necessary for optimum performances. This suggestion then is similar to other proposals concerning arousal, but relies upon the construct of inhibition as opposed to excitation. He summarised a number of studies investigating the effects of exercise on tasks which required a great deal of inhibition for successful performance, such as steadiness and static balance (Ross et al 1954, Gutin et al 1974). In all cases, a decrement in performance followed an increase in exercise, and, in his own experiment on steadiness, he found that even light exercise at a heart rate of 100 beat per minute was sufficient to lower performance. This decrement increased by 181% when heart rate was increased to 160 beats per minute, and when measured four minutes after the exercise, unsteadiness was still 28% greater than in the pre-exercise performance. Certainly no inverted U relationship appeared in these experiments.

At the opposite end of the continuum were skills which Gutin (1973a) suggested were dependent on disinhibition or excitation for successful results, and were typified by tasks requiring speed of movement. A review of studies using this type of task, indicated that they were best performed under conditions of maximum arousal level. (Phillips 1963, Ross et al 1954, Levitt and Gutin 1971). Gutin used the movement time results from his study with Levitt as the basis for the hypothesis that any investigation of the relationship between physical activity and this type of task would not yield an inverted U but a positive linear relationship. It is possible that this could also be the case in reaction time tasks where few choices are involved, and presumably little of the subject's processing capacity is required to perform the task.

Studies on tasks at opposite ends of the inhibition continuum have resulted in clear cut findings. Yet studies using skills from the middle of the range are far from conclusive. Attempts by Gutin (1973b) to clarify this area of uncertainty by using various reaction time tasks and suggesting some quantification of the inhibition involved in them have been unsuccessful. He lamented the fact that in his proposition there was a "lack of clear quantitative definition of inhibition", and hoped that "perhaps someone with more training in psychology can suggest a classification scheme which would integrate tasks which are more or less dependent on sensory acuity, central processing, and motor output." (p.265). Welford (1968) has suggested that the concept of inhibition is unnecessary to the understanding of the inverted U hypothesis; his model of arousal relies solely on the dimension of excitation.

Fiske and Maddi (1961) have also struggled with the problem of task difficulty, and have proposed the relationship illustrated in Figure 3 in which the range of optimum arousal for maximum performance becomes narrower as the task becomes more difficult. Welford (1972)

FIGURE 3



The effect of task difficulty on the relationship between quality of performance and the degree of arousal.
From Fiske and Maddi (1961).

has suggested however, that, rather than a narrowing of the inverted U, the curve should decline earlier, partly because difficulty itself was a form of stress or arousal, and partly because of a reduction in the subject's maximum capacity as a result of the high level of arousal. Martens (1974) implied that the dimension of the amount of energy that must be expended to undertake the task was also of considerable importance. When all these factors are combined, as they are in a whole range of motor skills, it is little wonder that it is difficult to determine the desired level of arousal to obtain optimum performance.

A number of other factors have been shown to have some effect on the arousal-performance relationship. As stated earlier, Davey (1974) found individual differences in the ability to withstand high levels of arousal, when subjects were classified in accordance with Eysenck's (1967) measure of introversion - extraversion. Welford (1973) has made the point that individuals probably differ in their resting level of arousal, as well as in their responses to changes in arousal level. He has suggested that individuals with a low resting level may have more tolerance for noisy environments, bright colours, and continual social contact. They may need stimulation in order to be optimally aroused, and to meet the exigencies of life most efficiently. Conversely, those with high resting levels may be over sensitive, and therefore keep levels of external stimulation down to prevent their becoming over aroused. Obviously situational factors such as audience and competitive settings are going to have some bearing on the way that different individuals perform. There are certainly many factors which qualify the relationship which exists between arousal and performance.

3.7 AROUSAL AND THE HANDICAPPED

In relation to the present study, some research has been conducted on the arousal-performance relationship among mentally retarded and psychiatric individuals. Evidence seems to suggest that some persons tend to be under aroused, or in Welford's (1965) terms, have a low resting level of arousal. Many researchers working with the mentally retarded, have proposed that they can be classified in these terms. Holden (1965) tested several hypotheses to explain the longer simple reaction time frequently found in the mentally retarded. His results were interpreted as strong support for the "subnormal prestimulus arousal hypothesis" (p.189) or the arousal deficiency hypothesis. Together with Baumeister et al (1965), he proposed that increased intensity of cues could overcome this problem, by both facilitating and maintaining a central process which alerted and prepared the retarded for the task.

Baumeister and Kellas, (1968a) observed that "normal" subjects appeared to work closer to their peak in reaction time experiments, while retarded subjects appeared to suffer from some attention or arousal lag. They agreed with Holden that this lag, or deficit, could be overcome by increasing the intensity of some of the relevant cues to which the subject had to attend. Further, they observed that retardates were unable to continually perform near their optimum level, and they suggested that this may be more descriptive of their problem than an inferior level of performance.

A number of investigators (Berkson and Mason 1964, Baumeister and Forehand 1973) have noted that many of the stereotyped or repetitious motor acts and postures, typical of the mentally retarded, can best be explained in terms of their general arousal level. However, there appears to be considerable debate as to whether this type of behaviour supports the arousal deficit hypothesis or the opposite point of view that the retarded are over aroused. (Baumeister and Forehand 1973). The difficulty with investigations in this area as with other work cited above, is that, in the absence of an independent measure of arousal, it is often possible to interpret results in terms of both over and under arousal. So, many investigators (e.g. MacMillan 1969, Holden 1966), have proposed that the lack of motivation and ready acceptance of failure shown by retarded people reflect under arousal. They have argued therefore, that retarded persons need more stimulation from external sources than the normal population.

A recent investigation of various work areas in a vocational rehabilitation centre found that retarded workers tended to be located in jobs where noise levels, demands for speed, exactness and teamwork were relatively high (McEwen 1973). This appeared to support the hypothesis that such people are under aroused, and can, therefore, withstand more stress and noise before their performance deteriorates. In the same study psychiatric rehabilitees were found mainly in less stressful work situations where noise levels and demands were low. This supported suggestions that such people often tend to be over aroused (Lang and Buss 1965). Welford (1965, 1973) has suggested that the mentally ill might be expected to show introvert characteristics in an exaggerated form, and with high resting levels of arousal, would be sensitive and eager to keep external stimulation at a low level in order to reduce the chances of becoming over aroused. These suggestions by Welford seem to be reflected in the work situations which were observed in McEwen's study.

An unpublished doctoral dissertation by Stoner (1972) considered the effects of exercise on the performance and learning of a stabilometer task, using a sample of educable mentally retarded teenagers. Pretask exercise on the bicycle ergometer for two minutes, at either ¼ or ½ maximum effort, neither hindered nor enhanced learning or performance. The linear nature of the learning curve which he obtained was not surprising, because it was unlikely that the prescribed amount of exercise was sufficient to fatigue the subjects, and any such effect obtained would have dissipated during the task trials. Failure of the exercised groups to learn or perform the task any better than the non-exercised group may simply have reflected that any change in arousal level caused by performing the novel task was comparable to the low arousal level of the exercise on the bicycle ergometer.

There is an absence of research investigating the effects of varying levels of physical activity on the motor performance of handicapped groups. It would be interesting to know if the effects of exercise follow the inverted U model of the arousal hypothesis so frequently found in normal populations.

CHAPTER 4

4.1 INTRODUCTION

In the light of previous work investigating the phenomenon of arousal, it seems that physical exercise, or activity, is readily accepted as a means of altering the arousal level of individuals (Gutin 1973a). Furthermore, many studies have found an inverted U relationship between changing levels of arousal and performance on a variety of tasks. However, it has proved difficult to quantify changes in arousal following exercise, and to classify different tasks according to the extent to which performance is influenced by exercise.

Some research has suggested that mentally retarded individuals may be under aroused, or have a low resting level of arousal. Yet the proponents of the arousal deficiency hypothesis are not without their opponents. As stated earlier, some researchers have argued that retarded persons are over aroused (Baumeister and Forehand 1973). The problem with both positions is that the arguments are frequently circular in that the dependent variable is used both as an index and as a definition of arousal; negative results can be blamed on the treatment variable and not the theory. The use of a reliable means of monitoring arousal, independent of the variable used to measure the effects of arousal, should help to resolve this problem.

It frequently seems to be the case, that supervisors in rehabilitation centres express the opinion, that a low resting level of arousal is the cause of the poor work performance of mentally handicapped persons on the production line. Some have expressed this idea after observation of apparent low levels of physical fitness among retarded individuals, and have extended the opinion to also include many of the psychiatric rehabilitees in these institutions.

The major purpose of this investigation was to examine the effects of physical exercise on the performance of both mentally retarded and psychiatric rehabilitees, and to see whether performance might be improved by hypothesised changes in the level of arousal, due to varying levels of physical activity. An attempt was made to examine the results in relation to the inverted U hypothesis.

4.2 METHOD

4.2.a. SUBJECTS

Forty handicapped adults from a vocational rehabilitation centre served as subjects, together with 20 non-handicapped adults drawn from a College of Advanced Education and an Institute of Fitness, Research and Training. Twenty handicapped subjects were classified as mildly retarded and 20 as psychiatrically disturbed, on the basis of scores on the Weschler Adult Intelligence Scale (WAIS) and their medical histories. There were 10 males and 10 females in each of the three groups. Descriptive statistics for age and IQ are shown in Table I. No IQ scores were taken for the non-handicapped group as it was felt unnecessary because of the nature of the sample. Ages of all subjects were within the range of 15 to 40 years. The upper limit of 40 years was chosen because it is generally regarded as inadvisable to subject people over that age to strenuous levels of physical activity without a comprehensive medical examination (Weiner and Lourie 1969). All subjects volunteered to participate, and none had known additional physical or neurological disabilities. Some of psychiatrically disturbed group were receiving some form of drug therapy.

TABLE I

Means and ranges for both WAIS full scale scores and ages of male and female retarded, psychiatrically disturbed and non-handicapped subjects.

SUBJECTS

		Retarded		Psychiatrically Disturbed		Non-Handicapped	
		Men	Women	Men	Women	Men	Women
Age	Mean	19	22	27	28	29	24
(Years)	Range	15-27	15-34	19-38	18-38	20-37	18-32
IQ	Mean	67	64	101	93	Assumed above	
Scores	Range	47-80	51-77	85-119	87-100	average	

4.2.b. APPARATUS

Bicycle Ergometer: The Monark bicycle ergometer shown in Figure 4 was used to determine the physical work capacity (PWC) for each subject, and to control work loads during the experiment. Adjustable tension on the belt around the wheel causes the belt to act as a mechanical brake in such a way that the amount of work, performed when pedalling at a determined rate, can be graded. The work done by the cyclist involves activity by large muscle groups; an essential prerequisite for an analysis of the oxygen transportation system and hence cardio-respiratory fitness. The task is simple and can be assumed to demand about the same energy output irrespective of age, familiarity with cycling, or degree of physical condition (Astrand 1972).

Reaction Time: Stimuli were three lights 8 mm in diameter, set 52 mm apart, and mounted 30 cm from the subject. A response was made by pressing one of three flat-topped keys, located immediately below the stimulus lights. A "home" key was situated nearer to the subject and at an equal distance of 43 mm from each of the other three keys. The complete apparatus is shown in Figure 5.

This arrangement enabled reaction time (RT) to be separated into two components:

(a) decision time or the time taken to lift the finger from the home key,

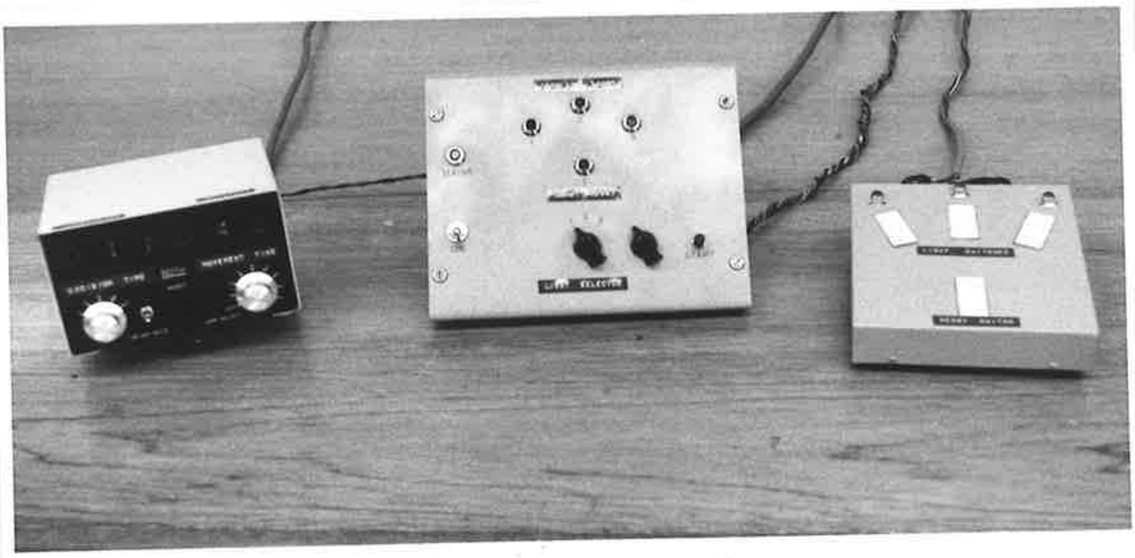
(b) movement time from the "home" key to the depression of one of the three response keys.

Both components of reaction time were recorded with 10 millisecond accuracy from the onset of the stimulus light to the depression of a response key. The interval between trials varied between six and nine seconds while the preparatory interval between depressing the "home" key and the appearance of the next signal ranged from one to four seconds.

FIGURE 4

Monark Bicycle Ergometer

FIGURE 5



Three Choice Reaction Time Apparatus

Left - Timer for decision and movement time
Centre - Light selection panel for the experimenter
Right - Light and key panel for the subject

4.2.c. PROCEDURE

Physical Work Capacity: Because of difficulties associated with the measurement of maximum oxygen intake (MvO_2) by direct means (Shephard et al 1968), PWC was established for all subjects, using a procedure which involved submaximal levels of work. This procedure followed recommendations by the Toronto Working Party (World Health Organisation 1967). Handicapped subjects were tested at the rehabilitation centre, under conditions as near as practically possible to those existing in the laboratory in which non handicapped subjects were tested. All subjects wore light comfortable clothing which facilitated heat exchange.

Subjects were required not to have exercised, eaten or smoked for at least one hour prior to testing. The seat and handlebars of the bicycle were individually adjusted so that the leg was almost completely extended when the pedal was in its lowest position; this was to ensure mechanical efficiency. Subjects pedalled in time to a metronome set at 100 beats per minute, so that the wheel made 50 revolutions each minute.

Each subject was first given sufficient practice to become familiar with the task, and every attempt was made to allay any anxiety induced by the experimental situation, as this could result in non metabolic increases in pulse rate, thereby limiting the accuracy of the procedure (Shephard et al 1968b). A qualified nurse was present at all times.

For each subject, a sequence of three submaximal work loads was chosen, so as to result in a range of heart rates from approximately 110 to 165 beats per minute. Each test lasted four minutes, the progressive time of only 12 minutes minimising the possibility that rise in pulse rate could be spuriously increased by increases in deep body temperature (Shephard 1967). Work rates varied for each subject, and were adjusted during testing, in accordance with estimated maximum oxygen intake (MvO_2) obtained by responses to earlier work loads. Heart rate was recorded during the last 15 seconds of the third and fourth minutes of each of the three work periods. Samples at these times ensured that increases in circulation had ceased, and that a steady heart rate had been attained. Subjects rested for one minute while seated on the bicycle following each work period.

From the graphed results of the test, physical work capacity 150 and 170 (PWC 150 and PWC 170) were individually calculated. Both estimates were taken to allow comparisons with other research, some of which have used these measures. Astrand's nomogram was used to calculate predicted maximum oxygen intake (MvO_2), which was then corrected for age (Astrand and Rodahl 1970). Maximum work load was calculated, and from this four work loads for each individual were chosen, to fall within the ranges of 25-35%, 45-55%, 65-75% and 85-100% of their maximum figure. These ranges ensured that each subject experienced a light, moderate, comparatively heavy, and very heavy work load, dependent upon the maximum load for that person. These loadings, based on the individual capacity for each subject, were chosen rather than fixed work loads for all subjects which might have been severe for some and comparatively light work for others. Each exercise session lasted three minutes; in exceptional cases where the subject was unable to continue pedalling for the full three minutes, the exercise period was shortened.

Reaction Time: Each subject completed a minimum of 30 practice trials. Where this appeared insufficient, additional practice trials were given until responding was comparatively consistent, conformed to the set procedure, and the experimenter was satisfied that the subject had mastered the task. Following practice, the subject completed five runs of 30 trials; runs were interspersed with the four exercise sessions which progressed from light to heavy. Within each run, the appearance of a light was determined from random number tables, with the constraint that all lights were equiprobable within the 30 trials. During reaction time trials, each subject was instructed regularly to respond as quickly and accurately as possible. A set of 30 trials took between four and five minutes, and the whole procedure for each subject lasted approximately 45 minutes. An incorrectly depressed key was recorded as an error; when a key was not depressed cleanly so that the timer continued to accumulate, the response was recorded as a "miss".

4.3 RESULTS AND DISCUSSION

4.3.a. SPEED DIFFERENCES BETWEEN THE GROUPS

Two way analyses of variance (group x sex) were carried out for decision time and movement time separately. A different analysis was done for each level of exercise. Complete AOV tables for these analyses are included in Appendix IIA and IIB.

Results in Table 2 show that retarded subjects were markedly slower than the non handicapped sample. This was for reaction time performance following all levels of physical activity on the bicycle. The significant differences between non handicapped and retarded subjects were evident on the measures of both decision time and movement time. These results are summarised in Figure 6.

TABLE 2

Mean Reaction Time (R.T.) for retarded, psychiatrically disturbed and non handicapped subjects in a three choice R.T. situation, with increasing levels of physical exercise following tasks one to four.

DECISION TIME (msec)

GROUP

	R.T. Measure	a Non handicapped	b Retarded	Difference (b - a)	c Psychiatrically disturbed	Difference (c - a)
Exercise Level	0	330	457	127 *	449	119 *
	1	317	428	111 *	425	108 *
	2	313	418	105 *	415	102 *
	3	311	412	101 *	416	105 *
	4	312	392	80 *	410	98 *
	OVERALL	317	421	104 *	423	106 *

MOVEMENT TIME (msec)

	R.T. Measure	a Non handicapped	b Retarded	Difference (b - a)	c Psychiatrically disturbed	Difference (c - a)
Exercise Level	0	123	190	67 *	175	52 *
	1	126	191	65 *	168	42 *
	2	125	183	58 *	164	39 *
	3	125	183	58 *	167	42 *
	4	118	186	68 *	163	45 *
	OVERALL	123	187	64 *	167	44 *

* Significant at 0.05 level

FIGURE 6

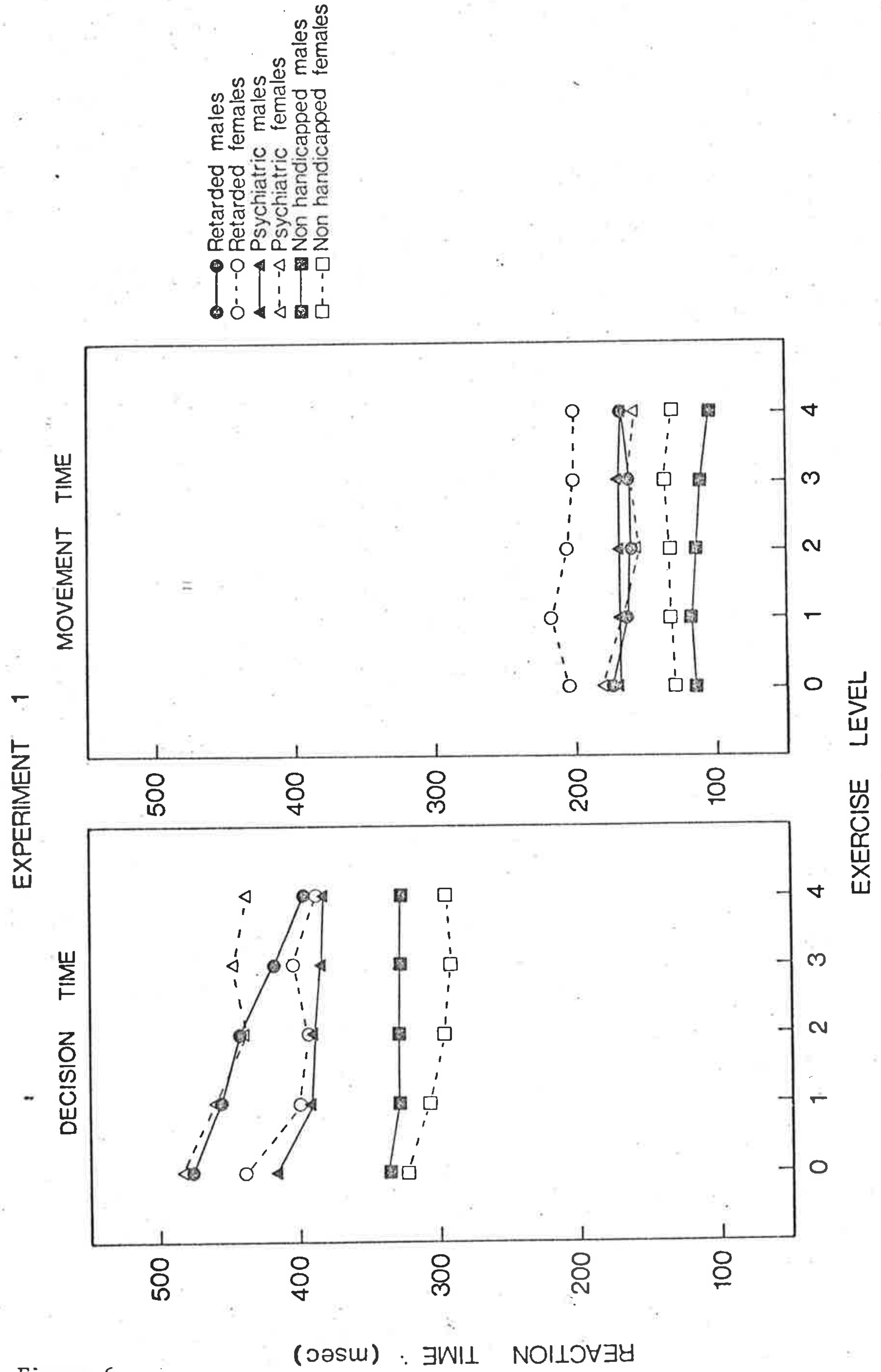


Figure 6. Mean decision and movement time scores in a three choice reaction time task for non handicapped, retarded, and psychiatrically disturbed subjects following exercise at increasing levels of intensity.

They were, therefore, in line with the widely reported findings in studies using reaction time as a measure of performance, of a negative relationship between response latency and intelligence within a certain range of ability. (Baumeister and Kellas 1968a). These investigators concluded that the few studies which failed to confirm the relationship have either used "subjects within an extremely narrow range of ability or have employed older defectives." (p.168).

When attempts have been made to explain the relationship between speed and intelligence, several hypotheses have received support. Bensberg and Cantor (1957) noted changes in the correlation according to whether the defectives were diagnosed as "familial" or were classed as brain injured. The former obtained a far more substantial correlation between mental age and reaction time. Dingman and Silverstein (1964) criticised many of the studies investigating the relationship, on the basis that they failed to control for the important variable of motor disabilities from which many mentally retarded persons suffer. Rather than rely on clinical judgements, they tested the effects of these disabilities directly by controlling for them in their study. Their results suggested that, at least in part, the negative relationship between reaction time and mental ability could be attributed to the absence of adequate controls on the variable of motor disabilities. The investigators appeared to suggest even further, that the likelihood of error, in support of the relationship, tended to become greater as the degree of perceptual and motor skill, involved in the performance task, increased.

In this investigation no direct controls were attempted, although the personal files on all mentally retarded subjects were carefully examined, and any subjects who had evidence of motor or sensory defects were eliminated from the sample. It could also be suggested that the performance task involved in this study was of such a simple nature, that any differences in motor ability would have been at a minimum.

Despite the absence of IQ scores for the non handicapped group, correlations between IQ and decision time performances both at pre-exercise and the mean of post exercise levels were examined for the handicapped groups, to see if the correlations found in other studies (Scott 1940, Ellis and Sloan 1957, Berkson 1960) occurred in this investigation. The correlation coefficients in the male sample were -0.514 ($p<0.01$) and -0.432 ($p<.05$), and in the female sample -0.254 and -0.269 respectively, both of which were too low for statistical significance.

Several explanations can be offered for the very poor correlations found in the female sample. As shown in Table 1, the much smaller range of IQ scores within the retarded and psychiatrically disturbed group would have made a significant correlation coefficient much harder to achieve. In addition, the majority of the psychiatric females were under constant medication; this may have resulted in the poorer decision time performance for these subjects than was found for a number of their mentally retarded counterparts.

The non handicapped subjects were significantly faster than psychiatrically disturbed subjects for both decision and movement time at pre-exercise and following all four exercise levels. As shown in Table 2 and in Figure 6, latencies for both the psychiatrically disturbed and some mentally retarded subjects were similar on both performance measures through all exercise levels.

No statistically significant sex differences were found on decision time performance within each of the three groups at any level. Although the mean sex differences on movement time were considerably larger for all but the psychiatrically disturbed group, differences only reached statistical significance after the first session of physical activity :- (Level 1 in Appendix IIB(b) or 25-35% exercise level in Figure 6).

Figure 6 suggests significant interaction between the groups and sexes on decision time at all levels. Analysis of variance tables in Appendix IIA confirm this interaction was statistically significant. Non handicapped women were faster than men at all levels and the gap widened as the exercise level increased, with the exception of the performance following level 4 which was the most strenuous of the exercise periods. Mentally retarded women were also faster than their male counterparts, and yet the discrepancy narrowed as the exercise level was raised. In contrast, the psychiatric women were markedly slower than the men, and, although the difference did decrease slightly, it was still rather large at all levels. Figure 6 indicates that the reverse situation was found with the measure of movement time, but at no level did the interaction between the groups and sexes reach statistical significance.

In the light of previous research which has established a negative relationship between R.T. and scores of intelligence, it is interesting that psychiatric subjects in this experiment were not significantly faster on the performance task than the mentally retarded subjects. They were, on average, 32 points higher on the

WAIS full score. Their poor reaction time scores may have been due to either the nature of the mental handicap involved, or to treatment involving drugs, or both. Generally, descriptive classifications used for these subjects were very broad or often rather vague.

It was, therefore, difficult to relate these classifications to results obtained with these subjects, except to note that those not receiving medication were classified either as schizoid personality, inadequate personality, or acute melancholic. All three of these disorders typify persons who are depressed or withdrawn, and might be expected to be under aroused rather than over aroused.

The majority of those receiving medication were classified as schizophrenic, and an examination of the pharmocological treatment revealed a variety of drugs which all had the effects of tranquillisers or sedatives lowering alertness and slowing motor processes. These subjects may, therefore, have been in the same state as that commonly suggested for mentally retarded persons; i.e. having a low resting level of arousal (Welford 1973). A comparison of the male and female psychiatric samples' results on decision time confirmed that treatment may have been the most important factor resulting in the suggested low resting level of arousal. The females were much slower than their male counterparts, and it was interesting to note that constant medication had been prescribed for eight of the ten women, whereas this was so for only four of the men.

Some research has indicated that males are faster responders than females in simple R.T. tasks (Scott 1940). However, results from this investigation suggest that if any such difference does exist in non handicapped populations, then it is due to movement components, rather than central or decision making processes, in which the women were faster in this study. Fleer (1972) did find a significant sex difference in a group of retardates whom he tested on reaction time, but unfortunately he failed to indicate in his work in which direction the difference occurred. He also reported that retarded men had faster movement times than females, which appears to be consistent with the findings from this experiment, although statistical significance for such a difference was only reached after one exercise level. Scott (1940) found sex differences in a retarded group in favour of the males. Yet again the results of the present investigation suggest the opposite, and appear in agreement with the concept supported by Welford (1973) that women have a higher resting level of arousal than men, and could thus be expected to perform better than the men in the early series of trials. The negative result for the psychiatrically disturbed group could be accounted for in terms of the medications prescribed.

4.3.b. VARIABILITY

A two way analysis of variance (group x sex) was carried out on the standard deviation scores obtained for each individual from the five decision time performance runs of 30 trials each. A complete analysis of variance table from this is included in Appendix IIIA. Significant differences (p at least <0.05) were found between both the sexes and the groups. The women were more variable than the men, and the non handicapped group was found to be markedly less variable than both the mentally retarded and psychiatrically disturbed rehabilitees.

A further two way analysis of variance (group x sex) comparing retarded and psychiatrically disturbed groups found no significant differences, although the retarded tended to be more variable than their psychiatric counterparts. The analysis of variance table is included in Appendix IIIB. These results did lend support to the frequent finding that retardates are more variable in their performance than are non retarded persons (Berkson and Baumeister 1967, Baumeister and Kellas 1968a), although the similarity between the handicapped groups cannot readily be explained except perhaps for those reasons already outlined on pages 57 and 58.

4.3.c. EXERCISE EFFECTS ON DECISION TIME AND MOVEMENT TIME

It was hypothesised that physical exercise might be a means of changing arousal level, thus reducing the reaction time of retardates and resulting in a convergence between their speed and that of the non handicapped sample. Changes in decision time and movement time following physical exercise sessions are shown in Figure 6. The results of a trend analysis of decision time scores using Jonkheere's mean tau can be seen in Table 3. A significant positive trend, indicating a decrease in decision time, was obtained for all groups with the exception of the normal male sample. It was not necessary to analyse trends in movement time data; Figure 6 indicates clearly the absence of any change as a result of the differing levels of exercise.

The significant improvement in decision time, as the demands of the exercise became heavier, suggests that physical activity is a means of improving reaction time performance of retarded and psychiatrically disturbed persons. However, the absence of any exercise effect on movement time indicated that these two parameters of performance were affected quite differently by increasing amounts

TABLE 3

Jonkheere's mean tau analyses of trend using individual mean decision time obtained in five sets of 30 trials from six groups of subjects.

Group	Mean tau	Z Score	Probability (one tailed)
Non-Handicapped men	0.160	1.162	>0.05
Non-Handicapped women	0.560	4.260	<0.01
Retarded men	0.800	6.119	<0.01
Retarded women	0.400	3.021	<0.01
Psychiatrically disturbed men	0.480	3.641	<0.01
Psychiatrically disturbed women	0.520	3.951	<0.01

of physical exercise. It would appear then that exercise influenced central decision making processes rather than peripheral processes concerned with such things as arm speed. This finding added further weight to the supposition that physical exercise might affect arousal mechanisms which are believed to be centrally located.

The results were interesting when considered in relation to the previous research done on the effects of physical exercise on performance. Sjoberg (1968) and Levitt and Gutin (1971) both found improved performance on a reaction time task while either pedalling a bicycle ergometer or walking on a treadmill. However, there are important discrepancies between their results and those of this investigation. They used non handicapped male subjects, and found significant improvement in reaction time at moderate levels of physical activity. The non handicapped males in this study did not show any significant improvement on any of the four levels of physical exercise. The earlier studies found a clear cut inverted U curvilinear relationship between the level of exercise and reaction time performance. It is clear from Figure 6 that this was not the case in the current investigation.

Several reasons may be offered for the absence of an inverted U relationship in this study. Subjects were required to exercise on the bicycle ergometer at various work loads for a period of three minutes. This time period was chosen because, with relatively heavy work loads, subjects frequently experience a feeling of local muscular fatigue or a sensation of pain in the thighs or knees. This can be quite disturbing for the subjects, and may cause them either to lose their tempo and thus lessen the work load, or even cease pedalling if their motivation is not high.

In experiments which varied the duration of exercise prior to a numerical task performance, both Davey (1974) and Gupta et al (1974) found that optimum performance occurred after exercise bouts lasting between two and five minutes. Gutin (1973) suggested that such evidence implied that prior exercise was curvilinearly related to numerical task performance, if duration rather than intensity of exercise was varied. The three minute exercise efforts may not have been of sufficient duration to lead to significant increases in the level of arousal in the non handicapped sample, and certainly were not long enough to cause any decrement in reaction time performance. There is little doubt, however, that the work loads were of sufficient intensity, as several subjects from all three groups were unable to complete the full three minutes of exercise on the ergometer at between 85 and 100 per cent of their maxima.

Sjoberg (1968) and Levitt and Gutin (1971) both used exercise periods of longer duration than those used in this investigation. Sjoberg required subjects to pedal for five and a half minutes, while Levitt and Gutin had subjects walk on the treadmill for a total of 12 minutes. It has already been mentioned that work on the bicycle ergometer can quickly lead to local muscular fatigue at moderately heavy work loads, and with a duration of five and a half minutes, it is not surprising that a decrement occurred at the higher loads in Sjoberg's study. Although the treadmill does not present problems of local muscular fatigue, it could confidently be expected that a work period as long as 12 minutes would be fatiguing, and lead to a slowing of reaction time. It may also be that the five choice reaction time task used by Levitt and Gutin (1971) was more demanding than the three choice reaction time task used in this investigation.

In addition to the duration of exercise and the difficulty of the task, the placement of the period of exercise in relation to the task may be of considerable importance. The two investigators cited above used concomitant exercise rather than exercise prior to the performance of the task. It appears reasonable to assume that, as the intensity of concomitant exercise increased, an increasingly greater degree of interference to information processing would have occurred. This might account for the decrement in performance at higher levels of work, leading to the finding of an inverted U relationship. Such interference would be minimal when the exercise was done prior to the task, and would not persist long after the exercise. Certainly, if heart rate is taken as an index of the level of arousal, then the level drops quite rapidly after the completion of the exercise.

4.3.d. CONTRAST OF EXERCISE EFFECTS ON PERFORMANCE BETWEEN THE THREE GROUPS

An interesting contrast between the effects of exercise on the performance task was found between the three groups of subjects. Two way analyses of variance (group x sex) were carried out for decision time and movement time separately, using the difference between pre-exercise performance and the mean of post exercise performances as scores. Relevant analysis of variance tables are included in Appendix IVA. A significant difference ($F=3.52$; df 2,54; $p<0.05$) was found between the groups but not the sexes on decision time. This was due to the marked improvement in both handicapped samples. In movement time there was a significant interaction effect ($F=5.37$; df 2,54; $p<0.01$)

due to improvement by retarded men and psychiatrically disturbed women, but slight deterioration by retarded women and consistent performance by psychiatrically disturbed men. It is not apparent why such an effect should have occurred.

Differences between decision time prior to exercise and following each exercise level were examined for each group of subjects using a series of related samples t tests. Results can be seen in Table 4. The non handicapped male sample did not show statistically significant improvement from pre-exercise to any post exercise performance. The mentally retarded men improved significantly after the second exercise session and continued to improve thereafter, while the psychiatrically disturbed males showed improvement after initial exercise but did not make further significant gains at higher levels of exercise. However, all three female samples showed significant improvement even after the first or lowest level of exercise, and continued to improve through all the subsequent levels.

A comparison of decision time performance following the two most strenuous bouts of exercise was done using a two way analysis of variance (group x sex). The table in Appendix IVB indicates a significant difference between the retarded sample and the other groups ($F=5.20$; $p<0.01$). Whereas the other groups appeared to reach a standard close to their optimum performance after about the third level of exercise, the retarded group, and in particular the men in that group, were still improving at the highest exercise level. It should be noted, however, that this could well be accounted for in terms of the poor level at which these men had performed in early trials on the task. It was only after the most strenuous level of exercise that they reached a decision time level comparable with a

TABLE 4

Results of related samples t tests on mean scores of decision time contrasting pre-exercise performance with each of the post exercise performances for all six groups of subjects.

Level	Non-handicapped				Retarded				Psychiatrically Disturbed			
	Men		Women		Men		Women		Men		Women	
	t value	p	t value	p	t value	p	t value	p	t value	p	t value	p
0 - 1	1.73	>0.05	2.77	<.01	1.49	>0.05	5.54	<.01	2.71	<0.05	2.72	<0.05
0 - 2	1.13	>0.05	3.77	<.01	2.95	<0.01	5.53	<.01	1.70	>0.05	3.48	<0.01
0 - 3	1.12	>0.05	3.83	<.01	4.80	<0.01	2.80	<.01	1.67	>0.05	3.13	<0.01
0 - 4	0.93	>0.05	3.89	<.01	6.74	<0.01	3.43	<.01	1.86	>0.05	3.54	<0.01

number of other groups. Despite the levelling off of performance in the other groups, no significant decrement in performance occurred at any level of exercise.

4.3.e. ERROR ANALYSIS

Several reasons have previously been suggested to account for the absence of the inverted U relationship frequently found in other studies of this type (see p.61). Yet one further comment is warranted. Welford (1962) has suggested that the effect of high levels of activation may not necessarily result in slower performance, but rather in a decrease in accuracy. Thus, in this study, the effect of the more strenuous exercise levels may not be observed as an increase in the reaction time, but as an increase in the number of errors and misses made by the subjects. An error occurred if the subject pressed an inappropriate light key; a miss was recorded if the subject failed to make contact with any key when responding to the chosen light. Table 5 shows the number of errors and misses recorded in the study. The low total number of errors (19) was probably a reflection of the simplicity of the reaction time task. There were obviously far too few for any trend to become apparent.

However, the total number of misses (201) was much higher and was worthy of some investigation and comment. It might be expected that, in accord with the "pay off" concept, the number of misses would have increased progressively as the level of exercise work load increased, and particularly at the two most strenuous activity levels. Yet no such progressive pattern of misses emerged. If errors are added to misses, then it is clear that "errors" did increase from pre-exercise performance to the first of the post exercise performances,

TABLE 5

The number of misses and errors recorded by non handicapped, retarded and psychiatrically disturbed subjects in the reaction time task.

MISSES

Exercise Level	Non handicapped			Retarded			Psychiatrically Disturbed			Overall Total
	Men	Women	Total	Men	Women	Total	Men	Women	Total	
Level 0	3	6	9	4	6	10	7	5	12	31
Level 1	9	7	16	4	13	17	4	4	8	41
Level 2	7	8	15	5	7	12	10	7	17	44
Level 3	6	7	13	8	12	20	6	6	12	45
Level 4	8	7	15	3	13	16	7	2	9	40
TOTALS	33	35	68	24	51	75	34	24	58	201

ERRORS

Exercise Level	Non handicapped			Retarded			Psychiatrically Disturbed			Overall Total
	Men	Women	Total	Men	Women	Total	Men	Women	Total	
Level 0	2	0	2	1	0	1	0	1	1	4
Level 1	1	1	2	0	0	0	0	4	4	6
Level 2	1	1	2	0	1	1	0	1	1	4
Level 3	1	0	1	0	0	0	1	0	1	2
Level 4	1	0	1	1	0	1	0	1	1	3
TOTALS	6	2	8	2	1	3	1	7	8	19

but thereafter remained relatively steady. There were also no marked differences between the groups. An investigation of individual subject results did not reveal any consistent correlation between increases in the number of misses and improvement in reaction time performance.

A consistent finding which did emerge was that, within all three groups, the sex sample which was the faster also recorded the most misses. In addition, when mean decision time over all five performance levels was correlated with the total of errors and misses for each subject, there was a tendency for a relationship in all groups. It was most marked in the psychiatrically disturbed sample, and least in the mentally retarded group. The effect was statistically significant for all subjects combined (Spearman Rho -0.242; $p<0.05$; one tailed), although clearly this outcome was not a very strong one, and the result would account for only a relatively small proportion of the variance. Thus it would seem that there was some pay off between speed and accuracy, but that accuracy, as measured by the number of misses, was not directly related to either increases in speed or level of exercise, but to some overall tendency or strategy governing speed of responding.

4.3.f. LASTING EFFECTS OF EXERCISE ON PERFORMANCE

While heart rate provides an indication of changes in the parasympathetic nervous system, it is clear that it cannot serve as an index of long term changes in arousal, since it drops rapidly after the cessation of exercise. In fact it has been shown that, even after very strenuous activity, the heart rate returns to normal resting level in approximately three to four minutes. The time taken for a set of 30 trials was between four and five minutes. The short term lasting effects of exercise were examined by comparing performance on the first 15 trials with the second 15 at each of the five levels.

A two way analysis of variance (groups x trials) was carried out for decision time using a different analysis for each level of exercise. Group mean decision times obtained from these analyses are shown in Table 6. Complete analysis of variance tables for these analyses are included in Appendix V . As expected, a significant difference was found between the groups in mean decision time at all five levels. However, no difference was found in the comparison of the two sets of trials, and there were no interaction effects. An examination of mean decision times, as shown in Table 6, found no dissipation of the effect of exercise on performance over the four or five minute task period.

Baumeister et al (1965) investigated the effects of stimulus intensity on the reaction time of both non retarded and retarded subjects. Tones ranging from 25 to 75 db were used as the reaction stimuli. They found that the non retarded subjects were faster than retarded subjects, and that the performance of both groups improved with increases in the signal intensity. They also observed that differences between the groups were least at the highest stimulus level. These results are in accord with those of the current study.

In the current investigation heart rate was not monitored after the completion of exercise on the bicycle, because of the disrupting effect it may have had on subject's performance on the reaction time task which followed immediately. We can be certain, however, that there would have been a marked decrease in heart rate as the person recovered from exercise. The consistency of decision time

TABLE 6

Mean decision time (msecs) during the first 15 trials and second 15 trials for subjects in the 3 groups at all five exercise levels.

LEVEL

Groups	0		1		2		3		4	
	1-15	16-30	1-15	16-30	1-15	16-30	1-15	16-30	1-15	16-30
Non handicapped	331	329	316	318	310	317	310	312	313	310
Retarded	462	453	424	432	416	420	417	408	395	397
Psychiatrically Disturbed	449	450	419	433	413	417	418	413	411	413
OVERALL	414	411	386	394	380	384	381	377	372	373

performance over the trial period might suggest that little change has occurred in the level of arousal during this time. This, therefore, casts doubts on the usefulness of heart rate as an index of change in the level of arousal. However, heart rate may still be as useful as any other index which has been proposed to this point of time. It may be that it is quite an accurate indication of initial increases in the level of arousal, but once the brain and autonomic nervous system have been activated to a certain level, the system maintains itself, and heart rate ceases to have any direct relationship with it. This would be in accord, at least in part, with the ideas proposed by Baumeister et al (1965). Perhaps even the initial exercise period was sufficient for the system to reach the point where it maintained itself for some period of time.

CHAPTER 5

5.1 INTRODUCTION

Whenever reaction time tasks have been used as a measure of performance, certain factors have been rated as having some effect on the results. All models of choice reaction time predict an increase in reaction time as the number of possible alternative signals increases. Such factors as the stimulus - response compatibility, the temporal uncertainty, and the number of practice trials are all believed to affect the slope of this increased reaction time.

Teichner and Krebs (1974), in an extensive examination of 59 visual choice reaction time studies, observed that the light-key combination tended to produce the shortest choice reaction time even after relatively low levels of practice, and when the number of alternative signals was less than four. The former of these observations had been made some years earlier, Welford (1968) proposing that it was due to the fewer translations necessary in this arrangement compared with other situations. Welford also suggested that practice had its principal effect on the translation mechanism between stimulus and response. Teichner and Krebs found that, where the number of alternative light signals was low, the effect of practice on reaction time was minimal. They concluded that the low choice reaction times found in such situations were barely improved, even after very extensive periods of practice on the task. This conclusion suggests that any learning effect as a result of continued practice on such a task could be ignored for a normal population.

In the current investigation a compatible light-key combination involving a three choice situation was used. It was therefore reasonable to expect that the choice reaction times obtained would be short, and not further influenced by practice if adequate initial practice was given. An examination of data presented in Figure 6 indicates that, in so far as the non handicapped men were concerned, this assumption was reasonable.

However, a review of the literature revealed that the learning effect of continued practice on reaction time tasks has not been researched for either retarded or psychiatrically disturbed populations. As retarded samples have been found to vary in a number of ways from non retarded populations in their performance on these tasks, it remained possible that there might be some learning effect as a result of practice. This might have spuriously increased the apparent improvement in their performance following exercise.

Order of exercise treatments were not varied randomly among the subjects in this investigation. It was felt that encountering very heavy, intensive exercise loads on the bicycle first, might have had a profound demotivating effect upon the handicapped groups. This might have influenced subsequent performance both on the bicycle and the reaction time task. Thus, the order was the same for all subjects, progressing from no exercise through to the level of greatest intensity of exercise. Subsequent observation of the subjects' reactions to the very heavy loads, particularly among the handicapped groups, confirmed that the precaution taken in the original design was justified. The alternative of including appropriate control groups to match the six experimental groups was impractical because sufficient, suitable handicapped subjects were not available.

The investigation which follows examined possible effects of continued practice on the three choice reaction time task for retarded persons.

No psychiatrically disturbed persons were included in this investigation. There were insufficient such persons of the required age and IQ at the Centre, and in any case the performance of the psychiatrically disturbed group in the main experiment was so similar to that of the retarded group, that it was felt unnecessary to include a separate group in the second study. Following Teichner and Krebs (1974), a non handicapped control group was also thought to be unnecessary.

5.2 METHODOLOGY

Ten mentally retarded adults from the same vocational rehabilitation centre were used as subjects. An attempt was made to match the sample of 5 men and 5 women with the retarded group used in the major experiment. Descriptive statistics of both samples can be seen in Table 7.

The three choice reaction time apparatus from the major experiment was used again in this study. The procedure was identical to that applied in the original design, except that a three minute rest period was substituted for the three minutes of exercise on the bicycle ergometer. Each subject completed five sets of thirty trials, resting quietly in a chair between sets.

5.3 RESULTS AND DISCUSSION

Data were not separated into sex groups, since no significant sex differences were found in the major experiment, and only small numbers were involved. Figure 7 shows that the performance of the

TABLE 7

A comparison of mean and range of WAIS full scale scores and ages of male and female retarded subjects used in the original major experiment and the second experiment.

		Age (years)		IQ Scores	
		Men	Women	Men	Women
Major experiment sample	Mean	19	22	67	64
	Range	15-27	15-34	47-80	51-77
Second experiment sample	Mean	19	22	67	64
	Range	17-22	16-30	50-78	52-73

mentally retarded sample in this follow up study was comparable to that of their counterparts in the major experiment. Their mean decision time of approximately 460 msecs at the pre-exercise level was almost identical to the value recorded for the retarded sample in the original investigation. Both groups also recorded remarkably similar movement times around 200 msecs. Standard deviation scores in the two experiments also showed marked similarity. A table comparing these scores is included in Appendix VIA. One way analyses of variance were carried out on mean and standard deviation scores for both decision and movement time. Complete analysis of variance tables are included in Appendix VIB and VIC. As might be expected from an examination of Figure 7, no significant differences were found on either of the measures ($F<1.0$ in all cases). The differences in decision time between retarded subjects in this experiment and the major experiment (experiment 1) were significant for the more strenuous levels of exercise (i.e. level 2, 3 and 4; unrelated sample t tests; at least $p<0.05$ in each case).

Subjects in this study did not improve during the five sets of 30 trials as a result of recurrent exposure to the task itself. This suggests that the assertions of Teichner and Krebs (1974), regarding the stability of performance in a choice reaction time light-key task involving few alternatives, are equally applicable to both non retarded and retarded populations, providing there is adequate practice beforehand. There is no reason to suggest that the psychiatrically disturbed group would have performed differently. It would, therefore, seem reasonable to conclude that the improvement in decision time found in the major study, was not the consequence of continued practice on the reaction time task, but due to exercise.

FIGURE 7

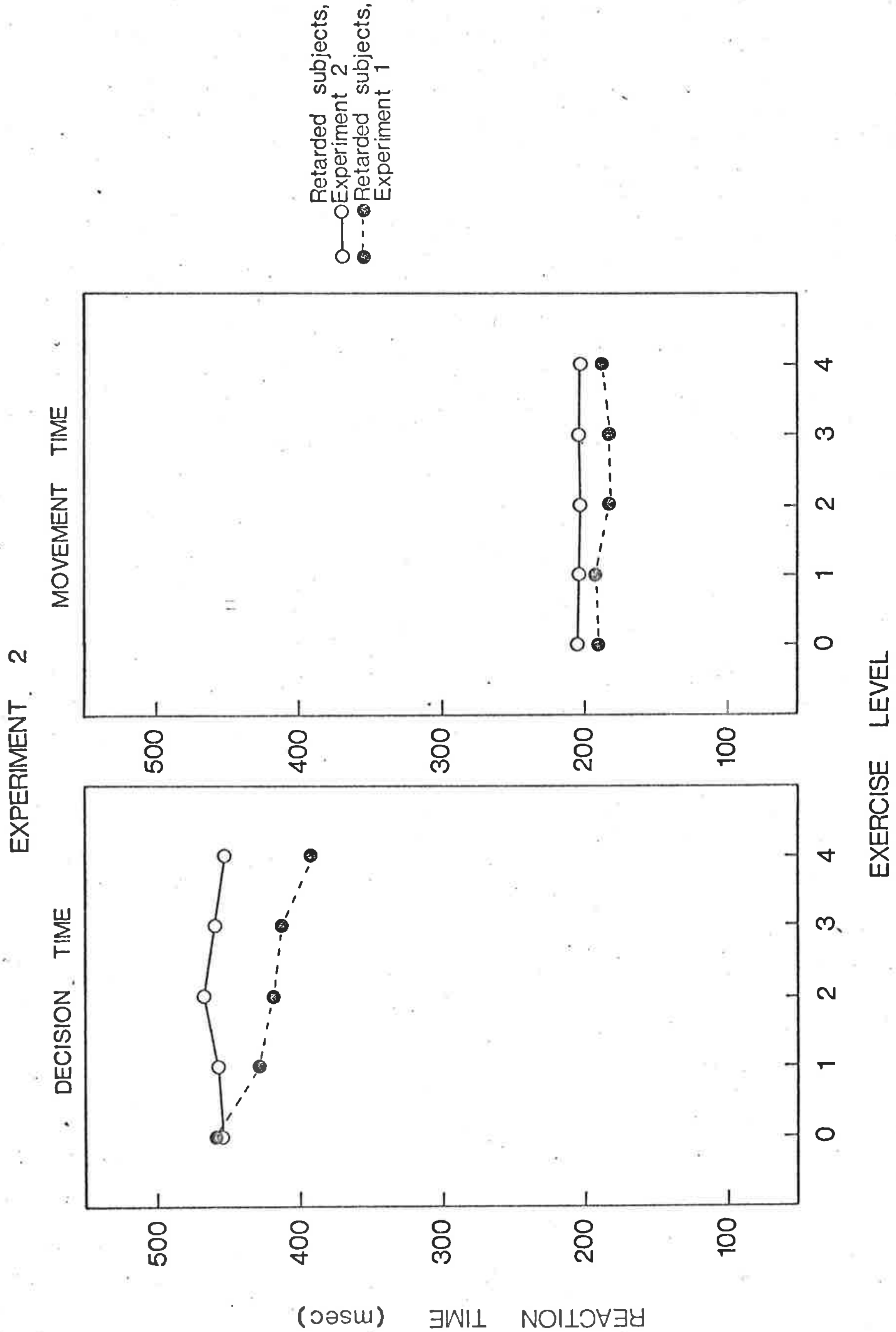


Figure 7. Comparison of mean decision and movement time scores for retarded subjects in experiment 1 and 2. In experiment 1 the reaction time performance followed exercise at increasing levels of intensity. In experiment 2 the reaction time performance was interspersed with rest periods of three minutes.

CHAPTER 6

In the major investigation PWC 150 and 170 were calculated for all subjects. The procedure used was recommended by the Toronto Working Party (World Health Organisation 1967), and involved a series of submaximal levels of work on a bicycle ergometer. Maximum oxygen intake (MvO_2) was then estimated from Astrand's nomogram (Astrand and Rodahl 1970). As these are commonly reported measures of cardio respiratory fitness, and as such are internationally recognised as worthwhile estimates, it was thought desirable to compare the measures obtained with similar samples from local and overseas studies.

Several different methods of reporting results have been used in such studies. Some authors have simply stated the pulse rate at a fixed level of oxygen consumption; others have indicated the PWC at a heart rate of either 150 or 170 beats per minute; while others have extrapolated to estimate the MvO_2. In this investigation the results will first be given in terms of PWC, and second as estimates of MvO_2, to allow more extensive comparisons with other samples.

6.1 PWC (170) RESULTS

A two way analysis of variance (group x sex) was carried out on PWC (170) scores. The complete analysis of variance table is included in Appendix VIIA. Significant differences were found between the groups and the sexes. Non handicapped males had significantly higher scores than both handicapped groups, while the differences between the retarded and psychiatrically disturbed did not quite reach statistical significance. In the female samples significance was only reached in the comparison between the non handicapped and the retarded group. These comparisons can be seen in Appendix VIIB and VIIC. In all three groups the men had higher PWC (170) scores than the women. This has been a common finding in studies comparing the sexes. Bengtsson (1956) found that, up to the age of 15, no appreciable sex differences occurred in the working capacity, but after that age, males showed a higher capacity than females.

Comparisons between these groups and non handicapped samples from both Stockholm (Sweden) and Winnipeg (Canada) are shown in Table 8. These were obtained from studies by Bengtsson (1956), Holmgren et al (1964) and Cumming (1967). In all cases, with the exception of the female samples from Winnipeg, the Adelaide handicapped persons were significantly poorer in terms of PWC (170). The level for the non handicapped male sample was comparable with overseas groups, while the female results were generally below those found in overseas studies. Other investigations using Australian populations have often found both men and women poorer than their counterparts overseas, and particularly those from Northern Europe. The small size of the sample used made it difficult to determine why this partial discrepancy may have occurred.

6.2 PWC (170) PER KILOGRAM BODY WEIGHT RESULTS

Frequently, results of physical work capacity or maximum oxygen intake are given in relation to body weight. In the same way that a large engine can perform more work than a smaller one, so a bigger body can develop more energy to do work than a smaller body. It is regarded as essential, therefore, that body weight be taken into account. PWC (170) is adequate if one is principally concerned with the absolute amount of work which a particular person can do, but is inadequate if comparisons are made between populations. Thus

TABLE 8

Mean physical work capacity (PWC 170) scores in kilopond metres per minute for subjects used in the major experiment (a) and from data obtained in a number of overseas investigations (b).

(a)

Men	PWC (170)
Non handicapped	1077
Retarded	734
Psychiatrically Disturbed	834

Women	PWC (170)
Non handicapped	681
Retarded	526
Psychiatrically Disturbed	560

(b)

Stockholm medical students	1111
Stockholm managers	1144
Stockholm physicians	1053
Winnipeg medical students	964
Winnipeg factory workers	1094

Stockholm nurses	840
Stockholm hospital assistants	727
Stockholm medical students	835
Winnipeg student nurses	515
Winnipeg graduate nurses	478

physical work capacity is most frequently given as PWC (170) per kilogram body weight.

Astrand and Rodahl (1970) have stated, "Since fatty tissue is metabolically fairly inert, but can constitute a large proportion of the body weight, it may be important to exclude it when evaluating the oxygen transporting capacity." (p.310). They advocated the use of the measurement of lean body mass rather than total body weight to overcome this problem. The World Health Organisation Scientific Group (1969) also reported that the ratio between lean body mass and total body weight underwent changes with development, and also with ageing. Also, even without noticeable changes in body weight, training could lead to increases in lean body mass at the expense of fat. Recently Gitin et al (1974) has challenged the use of lean body mass on the basis that it is "misleading in terms of evaluating the ability to do exhausting work" (p.759). Because of the controversy surrounding the use of this measure, and the considerable difficulty associated with calculating it, no attempt was made to use it in this study, and total body weight was the measure applied.

Table 9 shows PWC (170)/kilogram body weight for all groups. Post-hoc comparisons following a one way analysis of variance revealed no significant differences between the means of all three male groups, while only the non handicapped and psychiatrically disturbed females were significantly different. Comparisons can be seen in Appendix VIIIA, B and C. The differences between these results and those obtained using the simple measure of PWC (170) must be due to the inclusion of body weight in the latter comparison. This finding will be discussed when the measure of MvO_2 has also been included.

TABLE 9

Mean physical work capacity (PWC 170)/kg. body weight scores for all subjects.

	Non handicapped		Retarded		Psychiatrically Disturbed	
	Men	Women	Men	Women	Men	Women
PWC (170)	14.15 (1.94)	10.77 (1.79)	12.35 (3.53)	8.90 (3.04)	12.76 (3.22)	8.88 (2.52)

Standard deviation scores indicated in brackets.

PWC 150 and 170/kg. body weight of the retarded sample was below that obtained for a comparable group of retarded persons undergoing rehabilitational industrial training in Sweden (Nordgren 1970). The working capacity of the Swedish sample was 21% higher for men ($Z=3.25$; $p<0.01$; two tails), and 43% higher in the case of women ($Z=5.11$; $p<0.01$; two tails). This comparison is shown in Table 10.

Perhaps this result is not very surprising when it is remembered that normal populations tested in Australia were regularly found to have lower PWC scores than Northern European groups. Apparently retarded persons follow a similar pattern. This finding would seem to illustrate the depressed physical fitness levels in the Australian community generally.

Despite the small size of the sample, there is no reason to suppose that it is not representative of other retarded groups in the Adelaide community. Nordgren (1970) did not offer detailed information regarding the age of his sample, except to state that the range for men was 19 to 39, and for women 20 to 31. It would appear likely, therefore, that the Adelaide men had a lower mean age, while the female sample was comparable with the Swedish group. When the age difference in the male samples is considered, it only amplifies the problem.

6.3 MAXIMUM OXYGEN INTAKE (MvO_2) RESULTS

Shephard et al (1968b) answered the request from some investigators for direct reporting of PWC from submaximal testing, by suggesting that such reporting involved two deficiencies; firstly, the PWC measure provides no allowance for great variations

TABLE 10

A comparison of mean PWC (150) and (170)/kg. body weight scores between the retarded sample and a comparable sample in Sweden.

	Adelaide retarded group		Swedish retarded group	
	Men	Women	Men	Women
PWC (150)	9.61 (2.76)	6.48 (2.73)	11.98	10.06
PWC (170)	12.35 (3.53)	8.90 (3.04)	15.05	12.72

Standard deviation scores are indicated in brackets.

in maximum pulse rate with age; secondly, it does not take account of wide individual differences in maximum aerobic power within similar age groups. These investigators presented a strong plea for the use of predicted maximum oxygen intake (MvO_2).

Predicted maximum oxygen intake measures (MvO_2), in millilitres per kilogram body weight, are shown in Table 11 for all groups, together with results from a number of overseas studies, and a recent study by the Institute of Fitness, Research and Training (IFRT) in Adelaide (Cumming 1967, Crouch and Harris-Davidson 1975). Post hoc comparisons following a one way analysis of variance revealed no significant differences in MvO_2 between the three male samples, while the non handicapped female group had a significantly higher MvO_2 than both handicapped groups. Comparisons can be seen in Appendix IXA, B and C. It is interesting to note that both male and female non handicapped samples were slightly higher on MvO_2 than the IFRT group. This may simply reflect the small size of the sample used in this study, or possibly the greater readiness of these fitter subjects to take part in a study of this type. However, their scores are comparable with figures given in the overseas studies reviewed.

The discrepancies which exist following different modes of reporting results can be accounted for in a number of ways. Both Davies (1969) and Weiner and Lourie (1969) indicated that attempts to predict MvO_2, by indirect rather than direct measurement, were certain to involve errors in overall accuracy of between 12% and 15%. Regardless of this limitation, both studies concluded that these methods were still quite justified, and undoubtedly the best

TABLE 11

Mean maximum oxygen intake (MvO_2) scores in millilitres per kilogram body weight per minute of subjects in the major experiment (a), and from data obtained in a number of overseas investigations (b).

(a)

Men	MvO_2
Non handicapped	45
Retarded	40
Psychiatrically Disturbed	39

Women	MvO_2
Non handicapped	39
Retarded	33
Psychiatrically Disturbed	29

(b)

Stockholm average	52
Boston average	53
Dallas average	45
Norway average	44
S.A. Inst. of F.R.T.	41

California "Co-eds"	38
Stockholm housewives	40
Oslo office workers	36
Lapps average	41
S.A. Inst. of F.R.T.	37

available when comparing large groups. This suggests a second limitation present in this investigation. Both of these authorities indicated that the size of the sample had a considerable bearing on the accuracy of the estimation of MvO_2. Compensation for the loss of accuracy when using an indirect method could be obtained by increasing the number of subjects who were tested. Unfortunately the sample sizes used in the investigation reported here were too small to offset this problem of inaccuracy, and may have, in fact, contributed to failure to reach statistical significance in several of the comparisons made concerning work capacity.

Use of the measurement of body weight in the calculation of physical work capacity and maximum oxygen intake has obviously had a marked effect on the results. Both non handicapped males and females were, on average, heavier than their counterparts in the handicapped samples as seen in Table 12. This lowered their physical fitness indices when body weight was taken into account, thereby reducing the likelihood of statistically significant differences in the comparisons made. This was rather surprising as visual impressions suggested that the handicapped groups were, overall, carrying more body fat than the non handicapped group. Hayden (1974) has reported research indicating that retarded persons carry more body fat than non handicapped populations. Yet mean weight reported in this study was considerably higher in the male non handicapped group and also in the female group, although the difference was not as marked in the latter.

At the time the investigation was carried out, the height of subjects was not recorded. This is a pity since the difference in

TABLE 12

Mean weight in kilograms of male and female retarded, psychiatrically disturbed and non handicapped subjects.

	Non handicapped	Retarded	Psychiatrically Disturbed
Men	74.78 (61-89.5)	63.65 (39.7-109)	67.35 (51.8-89.8)
Women	63.32 (44.5-78.7)	61.09 (43.1-87.4)	62.80 (45.7-82.4)

Range indicated in brackets.

body weight may well have been related to differences in height within the groups. Unfortunately it was not possible subsequently to obtain this information, as many of the subjects had left the centre. It was my impression that subjects in the handicapped groups were somewhat shorter than those in the non handicapped groups.

Even if heights were approximately equivalent within each of the groups, the answer might well be in differences in body composition between the groups. A greater portion of the body weight of the non handicapped male sample could have been accounted for by muscle bulk, while body fat may have been predominant in the handicapped groups. The use of skinfold measures would have clarified this, while measures of height might also have been relevant to this question.

Contrast in the range of weight between the groups may also have been of some relevance. The non handicapped groups had a smaller range than the other groups with the males by far the most homogeneous. It was in the male comparisons that the introduction of the use of body weight caused the disappearance of statistical significance between the groups.

The great variability which is apparent in many areas of investigation among handicapped groups seems to be evident in the weight figures and physical fitness indices in this study. A glance at individual male results shows that the retarded sample contained both the highest and the lowest MvO_2, while the psychiatrically disturbed group had the second highest and second lowest scores. In three of these four individuals just mentioned, their weight figures occupied the opposite extreme positions. This suggests that, as has proved to be the case for so many other measures, wide variability between individuals may be the general rule for the measure of physical fitness in handicapped groups as previously suggested by Nordgren (1970).

Weingarten (1973) reviewed a number of studies investigating the comparison of performance on a range of mental tasks among groups varying in their level of physical fitness. He concluded from the evidence that the physically fit person had a definite advantage over the person of lesser fitness in performing mental tasks after some type of physiological stress. He did admit that this advantage was not apparent under normal conditions or on relatively simple tasks.

Correlations between physical fitness (MvO_2) and decision time performances both at pre-exercise and the mean of post exercise levels for all groups were investigated. The respective correlation coefficients for the total male sample were -0.085 and -0.1961, both clearly insignificant. In contrast, the correlation coefficients for the female samples were -0.6049 and -0.6042, both of which were significant at the .01 level of confidence.

Such a discrepancy between the sexes is rather surprising. Yet consideration of Figure 6 and Table 11 indicate that, while the three female samples corresponded in both their order on the performance and fitness measures, the men certainly did not. Closer scrutiny of individual subject data also revealed a much more haphazard arrangement of order among the men in comparison to the women. It appears then that there was no clear overall correlation between physical fitness and performance in this investigation. Whether this is a pattern which may be common, or simply a function of the task and small sample size used, remains unanswered.

CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 SUMMARY

A number of interesting findings emerged from this investigation.

Researchers have consistently found that retarded persons have slower reaction times than non handicapped people. Results in the major experiment confirmed this finding, the retarded sample being slower for both decision and movement components of reaction time at all five levels of performance. It has been suggested that these results may reflect the effects of motor deficiencies rather than outright differences in mental ability, but the results of this study do not support this suggestion. Reasonable procedures were adopted to control for this variable, although no direct action was taken within the experimental design. In contrast to the findings of several investigations, no significant sex differences were found in this study.

Results for the psychiatrically disturbed group were rather unexpected, in that their reaction times were consistently slower than the non handicapped group, and were comparable with the retarded group. It seemed likely that the constant use of tranquilliser or sedative type drugs may have been at least partially responsible for this result. This suggestion received some confirmation when correlations between IQ and reaction time were examined for the handicapped groups. The male samples, in which very few of the psychiatrically disturbed subjects were receiving drug therapy, returned a significant correlation. However, the female samples did not, and almost all of the psychiatrically disturbed females were under constant drug medication. Thus it could be suggested that, at least in this experiment, both handicapped groups were operating at approximately the same low level of performance.

Despite the controversy which surrounds the whole concept of arousal, most authorities have suggested that retarded persons suffer from an arousal deficiency which plagues their performance on many tasks. This investigation adds more weight to that proposition, and further suggests that psychiatrically disturbed persons who are required to take these types of medication may also be placed in a similar predicament.

It has been hypothesised that physical exercise is a means of increasing the level of arousal, and thus a means of improving performance on a variety of motor tasks. This study certainly indicated that exercise at increasing levels of intensity did lead to improvement in performance on the reaction time task. A second experiment suggested that this improved performance in the major investigation was essentially due to the effect of exercise rather than to a training or practice effect. A significant positive trend for improvement on decision time was found for all groups with the exception of the non handicapped males. However, this effect was not seen in movement time except in the psychiatrically disturbed female sample, whose results, as suggested earlier, were difficult to interpret because of the confounding effects of the medications these subjects were taking. On the basis of the different effect of exercise on the two components of reaction time, it was proposed that exercise may influence the central decision making processes rather than the peripheral areas primarily concerned with such things as arm speed.

The inverted U hypothesis, a model of arousal which suggested these experiments, appeared capable of explaining the relationship between arousal and performance. However, this model proposes that performance will improve to a certain point as arousal increases, but then any further increase in the level of arousal will lead to a decrement in performance. No such decrement was found in this study; all groups with the exception of the non handicapped males were still showing improvement in decision time - even though marginally - after the most strenuous levels of exercise. It has been suggested that the absence of the inverted U relationship was due to the format of the physical exercise used in this study. While the intensity of exercise on the bicycle ergometer was varied, the duration remained the same at three minutes for all levels. This design was chosen because of problems of local muscular fatigue associated with this apparatus. However, certain research has suggested that it may be more important to vary the duration of the exercise rather than the intensity, and where this has been done, an inverted U relationship has most often been obtained. It appears that a duration of approximately five minutes may be the critical level beyond which performance begins to deteriorate, provided, of course, that the intensity is sufficiently severe. The placement of the exercise also appears to be critical. When exercise has occurred simultaneously with the performance task, the inverted U relationship has been a common finding. With exercise prior to the performance of the task, findings have been far less consistent. It seems that, with increasing severity of concomitant exercise, there is an increasing degree of interference with information processing. Obviously the more demanding the task in terms of the amount of information processing required, the greater the degree of interference which might be expected. Thus, it can be argued that the short duration of exercise periods used in this study, its placement prior to the reaction time task, and the choice of a relatively simple task might all have been contributory factors in the failure to obtain an inverted U relationship.

An examination of the effects of the varying levels of exercise on performance indicated that it was the initial effects of exercise which had the most profound influence on decision time in the reaction time task. Reaction time improved markedly following exercise at the two lowest levels of work, and the implications of this finding will be considered further when recommendations are made in a later section of this chapter.

It is not possible to point to any definite long term effects of physical exercise on performance on the basis of findings in this study. The experimental design was such that effects lasting only four to five minutes were available for examination. However, within this time there was no significant dissipation of the effects of exercise; the initial improvement in reaction time performance was maintained throughout the whole trial period. This immediately throws some doubt on the use of monitored heart rate as an accurate index of arousal. While heart rate may be a relatively accurate index of initial increases in the level of arousal, a point seems to be reached when the system is sufficiently activated to maintain itself, and heart rate then ceases to be a useful means of monitoring further changes in the level of arousal. If this is the case, it would be of value to know how long the system, once aroused, can maintain itself at this higher level of performance. The current investigation suggests that the minimum period is at least five minutes.

One of the most consistent findings from investigations involving mentally handicapped persons is the greater degree of variability both between and within subjects when compared with non handicapped people. No attempt was made to examine within subject variability in this study. However, between subject variability in reaction time performance was examined, and results obtained were consistent with those outlined above.

The cardio respiratory fitness data of the handicapped subjects were interesting but rather difficult to interpret. Different modes of reporting the information, the small sample size used, and the lack of data on skinfold measurements and height of subjects made it impossible to present definitive findings. When body weight was taken into account, much of the statistical significance between the non handicapped and handicapped groups disappeared, although the tendency for a lower level of fitness in the latter groups was still apparent. Examinations of individual data did reveal a marked variability between individuals in cardio respiratory fitness, and this finding is in line with numerous studies in this area of research.

Although studies by Cumming et al (1971) and Nordgren (1970) both reported that handicapped groups were not significantly poorer in physical fitness than non handicapped groups, this is contrary to the general finding of poorer fitness levels among handicapped populations. It may be significant that, whereas these two studies used physical work capacity measurements for their fitness estimates, most of the other investigations used "fitness tests" which have recently been subjected to criticism; it has been suggested that they test certain specific skill factors rather than basic physiological functions. This does cast some doubt on the commonly accepted hypothesis that handicapped groups are poorer in physical fitness than non handicapped groups. There is a need for much more research, using the now widely accepted physiological measures, to clarify this proposition. In the meantime it is reasonable to suggest that handicapped persons do vary more widely in their level of physical fitness, and at least are marginally poorer than the non handicapped population, who, in turn, often appear to be slightly poorer than certain overseas groups.

7.2 RECOMMENDATIONS

Further research should aim to clarify some of the unresolved questions in the current investigation. Some attempt should be made to clarify the effects of exercise on performance by varying both duration and intensity of exercise, and by varying the placement of exercise in relation to the performance task. Reaction time is an excellent dependent variable to use in such studies, as has been suggested by Baumeister and Kellas (1968a), but it would be desirable to introduce other performance tasks involving greater demands on both perceptual and decision making processes. In the rehabilitation setting, this might lead ultimately to the use of a variety of work performance measures.

Further research is required to investigate the relationship between arousal and performance. While the inverted U model is the most widely accepted one in the explanation of this relationship, it has often been used in an essentially "post hoc" manner. It seems that future investigations should aim to bring together two lines of essential research; behavioural measures to identify and quantify the important psychological factors which mediate in the relationship, and neurological and physiological studies to further explain the arousal mechanisms and provide accurate indices of arousal. Heart rate was found to be a useful index in this study, but does not resolve the problem of monitoring possible changes in levels of arousal for prolonged periods of time. These questions are of vital importance to rehabilitation centres, where maintenance of good work production levels among the clientele is a basic problem. It would be valuable to know if changing arousal levels affect work performance, and if such changes persist for periods of time likely to be of significance in the work situation.

In the light of findings from this study, certain recommendations seem appropriate for Rehabilitation Centres. There may be merit in the introduction of a "pause gymnastics" type programme modelled on those used in overseas industry (Laporte 1966, Calder 1974), and particularly the programme adopted by a sheltered workshop in Brisbane (Calder 1974). The current investigation indicated that even a short three minute session of exercise on the bicycle at a low level of intensity was sufficient to cause an improvement in reaction time performance. In fact, most improvement in decision time for the handicapped groups occurred when the intensity was only between 25% and 35% of their maximum aerobic power (MvO_2). This is comparable with the level which might be expected from a "pause gymnastics" programme. Provided the exercises were carefully selected to meet the needs of the clients, and were adequately supervised by a trained physical educator, the programme might lead to benefit for both the clients and the Centre. Subjective assessments from other operative schemes have suggested that workers are more alert after such a break, and that work performance is not disrupted. If such a scheme were implemented it would be desirable that work performance in the Centre, and even aspects of social interaction, be objectively monitored so that the benefits could be assessed.

However, it must be realised that a "pause gymnastics" type programme is unlikely to be the complete panacea. As yet we are unaware of how long the effects of exercise of this kind will last. It could be that the effects of such a brief session of low intensity exercise would dissipate rather quickly. Thus, it would be imperative that work performance be monitored for quite a considerable period of time following exercise, in order to examine the long term effects of the activity session.

There are some conflicting findings on the physical fitness status of handicapped groups because of the different fitness tests applied. Yet it does seem reasonable to conclude that such people generally have a lower level of physical fitness, and certainly appear to show greater variability among themselves. An attempt to improve this situation would seem justifiable. It might be valuable to introduce regular exercise or recreation programmes within Rehabilitation Centres in an effort to improve the physical fitness of the clients. Where such schemes have been introduced, the benefits which have accrued have been widespread. Not only has there been marked improvement in physical fitness levels, but also positive changes in self concept, emotional stability, and general personality adjustment (Oliver 1958, Corder 1966, Leighton et al 1966). It has also been suggested that the cumulative effect of all these factors might have a positive influence on job proficiency (Leighton et al 1966).

Certain guidelines can be offered for any such programme. To have an appreciable effect on the physical fitness level of the clients, the programme should involve at least two half-hour training sessions per week (Saltin 1971). Saltin also suggests that with untrained subjects an intensity of work, equivalent to between 50% and 70% of their maximum oxygen intake, would be necessary to reach and maintain a satisfactory level of fitness. It is difficult to settle on any set prescription regarding the activities which should be included in such a programme. Handicapped persons are reported as poorer in motor skills than non handicapped groups (Bruininks 1974), and this would limit the choice of ball games and other similar team games. Because handicapped persons often appear to have limited skills in games of this type, they may be unable to perform at levels of work which are required to produce any beneficial effects on fitness level. However, where sufficient skill is evident, then recreational activities classified as moderate to heavy (Durnin and Passmore 1967) should be suitable for such a scheme. Many of the major games in physical exercise programmes could be modified and simplified in such a way so as to retain the physical benefits, while taking account of the lower skill levels of the handicapped clients. Particularly if such activities were supplemented with programmes involving running, cycling, swimming and series of exercises using the major areas of musculature, then some positive benefits should occur. The establishment of an objective programme of this type may help provide answers for the people working in the area of vocational rehabilitation. Many have been enthusiastic proponents of the value of recreation and improved physical fitness for their clients.

APPENDICES

TABLE OF CONTENTS

APPENDIX I A

PWC TEST

APPENDIX I A. 104.

DATE / / SEAT HEIGHT 6 NAME ____________

TEST NO. 1 BIKE NO. 3 IDENTIFICATION NO: ____________

Work Load kpm/min	heart rate/min. 2:45-3:00	heart rate/min. 3:45-4:00
600	128	130
900	150	150
1050	160	160

SEX MALE

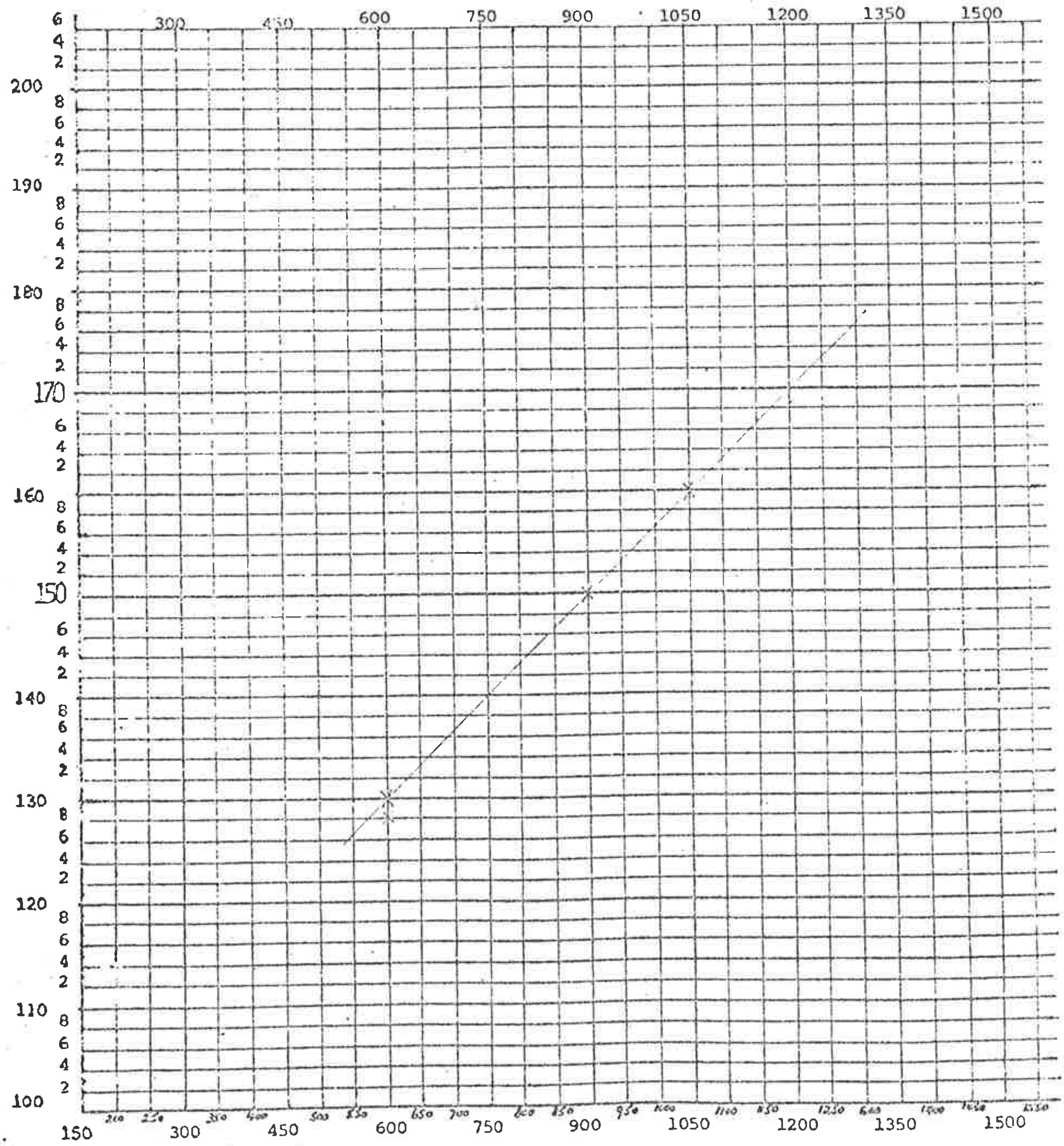
AGE 18 yrs. 4 mths.

HT. 174 cm. WT. 60 kgm.

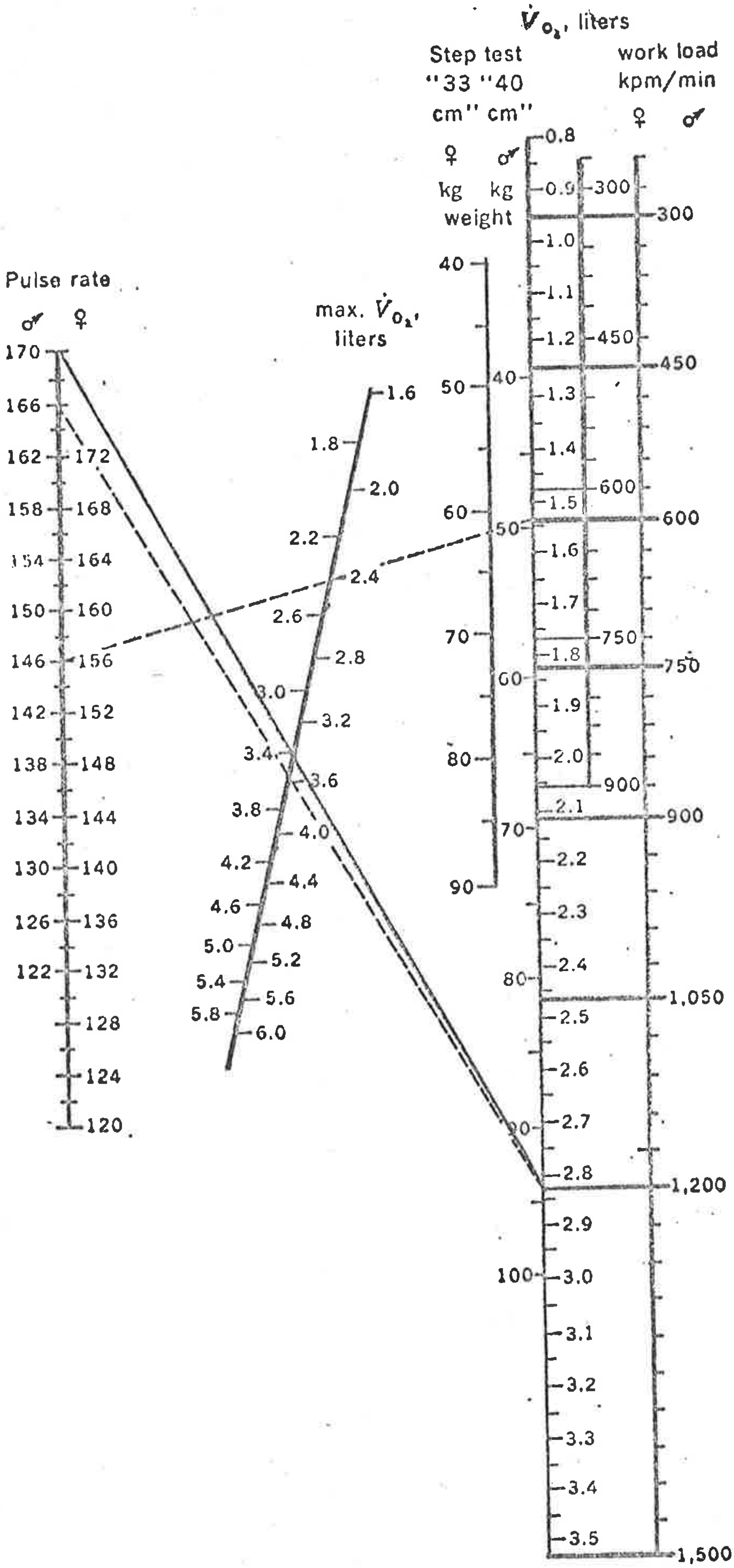
PWC 170. 1200 Per Kg/BW 20

m $\dot{V}O_2$ (L/min) 3.4 litres

$\dot{V}O_2$ Max.per.Kg/Bw. 56.7



APPENDIX I B



From Astrand and Rodahl (1970) p.356.

APPENDIX I C

CORRECTION FACTOR OF PREDICTED MAXIMUM OXYGEN INTAKE FOR AGE OR MAXIMAL HEART RATE

Age	Factor	Maximum Heart Rate	Factor
15	1.10	210	1.12
25	1.00	200	1.00
35	0.87	190	0.93
40	0.83	180	0.83
45	0.78	170	0.75
50	0.75	160	0.69
55	0.71	150	0.64
60	0.68		
65	0.65		

From Astrand (1972)
p.28.

APPENDIX I D

OXYGEN INTAKE OF VARIOUS WORK LOADS FOR SUBJECTS WITH A NORMAL MECHANICAL EFFICIENCY

WORK LOAD		OXYGEN INTAKE LITRES/MIN
WATT	KPM/MIN	
50	300	0.9
100	600	1.5
150	900	2.1
200	1200	2.8
250	1500	3.5
300	1800	4.2
350	2100	5.0
400	2400	5.7

From Astrand (1972) p.18.

APPENDIX II

A. Analysis of variance summary tables for all five levels of exercise. Groups consist of non handicapped, retarded and psychiatrically disturbed subjects. The dependent variable is the decision time component of reaction time.

(a) Level 0

Summary of Analysis of Variance

Source	SS	df	MS	F	P
Groups	203838.70	2	101919.35	30.84	<0.01
Sex	558.1504	1	558.1504	0.17	n.s.
Interaction	29467.300	2	14733.650	4.46	<0.05
Within cell	178431.50	54	3304.2870		
Total	412295.65	59			

(b) Level 1

Summary of Analysis of Variance

Source	SS	df	MS	F	P
Groups	159138.23	2	79569.117	19.62	<0.01
Sex	114.8164	1	114.8164	0.03	n.s.
Interaction	40503.234	2	20251.617	4.99	<0.05
Within cell	219045.90	54	4056.4056		
Total	418802.18	59			

(c) Level 2

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	142627.03	2	71313.517	16.72	<0.01
Sex	1653.7500	1	1653.7500	0.39	n.s.
Interaction	28911.100	2	14455.550	3.39	<0.05
Within cell	230329.10	54	4265.3537		
Total	403520.98	59			

(d) Level 3

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	141099.10	2	70549.550	18.22	<0.01
Sex	273.0664	1	273.0664	0.07	n.s.
Interaction	25296.434	2	12648.217	3.27	<0.05
Within cell	209100.40	54	3872.2296		
Total	375769.00	59			

(e) Level 4

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	115978.23	2	57989.116	16.69	<0.01
Sex	201.6665	1	201.6665	0.06	n.s.
Interaction	21823.433	2	10911.717	3.14	<0.05
Within cell	187633.00	54	3474.6852		
Total	325636.33	59			

B. Analysis of variance summary tables for all five levels of exercise. Groups consist of non handicapped, retarded and psychiatrically disturbed subjects. The dependent variable is the movement time component of reaction time.

(a) Level 0

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	49891.900	2	24945.950	10.72	<0.05
Sex	5940.1499	1	5940.1499	2.55	n.s.
Interaction	1037.7001	2	518.8500	0.22	n.s.
Within cell	125623.50	54	2326.3611		
Total	182493.25	59			

(b) Level 1

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	43697.033	2	21848.517	9.58	<0.01
Sex	7981.0667	1	7981.0667	3.50	<0.05
Interaction	8011.0332	2	4005.5166	1.76	n.s.
Within cell	123177.60	54	2281.0667		
Total	182866.73	59			

(c) Level 2

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	34768.533	2	17384.267	7.58	<0.01
Sex	4664.0166	1	4664.0166	2.03	n.s.
Interaction	8513.7334	2	4256.8667	1.86	n.s.
Within cell	123778.30	54	2292.1908		
Total	171724.58	59			

(d) Level 3

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	36163.900	2	18081.950	7.48	<0.01
Sex	5645.4000	1	5645.4000	2.34	n.s.
Interaction	5788.2999	2	2894.1500	1.20	n.s.
Within cell	130556.80	54	2417.7185		
Total	178154.40	59			

(e) Level 4

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	44237.200	2	22118.600	8.85	<0.01
Sex	3713.0667	1	3713.0667	1.49	n.s.
Interaction	7760.1333	2	3880.0667	1.55	n.s.
Within cell	134913.60	54	2498.4000		
Total	190624.00	59			

APPENDIX III

A. Analysis of variance summary table of standard deviation scores gained for all individuals from the five decision time performance runs of 30 trials each.

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	1079.2033	1	1079.2033	4.38	<0.05
Sex	40080.647	2	20040.323	81.27	<0.01
Interaction	1199.0466	2	599.5233	2.43	n.s.
Within cell	72500.020	294	246.5987		
Total	114858.92	299			

B. Analysis of variance summary table of standard deviation scores gained for both handicapped groups from the five decision time performance runs of 30 trials each.

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	836.4050	1	836.4050	2.43	n.s.
Sex	1215.2449	1	1215.2449	3.53	n.s.
Interaction	1185.8449	1	1185.8449	3.44	n.s.
Within cell	67503.860	196	344.4075		
Total	70741.355	199			

APPENDIX IV

A. Analysis of variance summary tables where the dependent variable is the difference between pre-exercise performance and the mean of post exercise performances. Groups consist of non handicapped, retarded and psychiatrically disturbed subjects.

(a) Decision Time

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	7303.6000	2	3651.8000	3.52	<0.05
Sex	904.8167	1	904.8167	0.87	n.s.
Interaction	1020.9333	2	510.4667	0.49	n.s.
Within cell	55993.500	54	1036.9167		
Total	65222.850	59			

(b) Movement Time

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	1346.1333	2	673.0667	2.10	n.s.
Sex	6.0167	1	6.0167	0.02	n.s.
Interaction	3444.1333	2	1722.0667	5.37	<0.01
Within cell	17306.700	54	320.4945		
Total	22102.983	59			

B. Analysis of variance summary table where the dependent variable is decision time performance on the two most strenuous levels of exercise. Groups consist of non handicapped, retarded and psychiatrically disturbed subjects.

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	4188.4000	2	2094.2000	5.20	<0.01
Sex	24.0667	1	24.0667	0.06	n.s.
Interaction	258.5333	2	129.2667	0.32	n.s.
Within cell	21765.400	54	403.0630		
Total	26236.400	59			

APPENDIX V

Analysis of variance summary tables. The dependent variable is mean decision time from trials 1-15 and trials 16-30 at all five levels of exercise for non handicapped, retarded and psychiatrically disturbed subjects.

(a) Level 0

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Trials	336.6758	1	336.6758	0.09	n.s.
Groups	408665.60	2	204332.80	53.24	<0.01
Interaction	452.5977	2	226.2988	0.06	n.s.
Within cell	437495.45	114	3837.6794		
Total	846950.33	119			

(b) Level 1

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Trials	1872.3008	1	1872.3008	0.40	n.s.
Groups	320463.95	2	160231.98	34.36	<0.01
Interaction	697.5488	2	348.7744	0.07	n.s.
Within cell	531631.50	114	4663.4342		
Total	854665.30	119			

(c) Level 2

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Trials	576.4063	1	576.4063	0.12	n.s.
Groups	286225.40	2	143112.70	30.54	<0.01
Interaction	24.2656	2	12.1328	.00	n.s.
Within cell	534278.25	114	4686.6513		
Total	821104.33	119			

(d) Level 3

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Trials	448.5332	1	448.5332	0.11	n.s.
Groups	282739.82	2	141369.91	33.32	<0.01
Interaction	617.5176	2	308.7588	0.07	n.s.
Within cell	483690.00	114	4242.8947		
Total	767495.87	119			

(e) Level 4

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Trials	20.8330	1	20.8330	0.00	n.s.
Groups	233420.82	2	116710.41	30.69	<0.01
Interaction	161.1152	2	80.5576	0.02	n.s.
Within cell	433553.60	114	3803.1018		
Total	667156.37	119			

APPENDIX VI

A. A comparison of mean decision and movement time scores of retarded subjects used in the original major experiment and the second experiment.

(a) Decision time

		a Major experiment retarded persons	b Second experiment retarded persons	Differences (b-a)
	Level 0	458 (80)	455 (79)	3
Exercise level	1	428 (98)	457 (78)	29
	2	418 (90)	467 (83)	49 *
	3	412 (71)	460 (74)	48 *
	4	396 (63)	454 (75)	58 *

(b) Movement time

		a Major experiment retarded persons	b Second experiment retarded persons	Differences (b-a)
	Level 0	190 (56)	205 (62)	15
Exercise level	1	191 (55)	204 (68)	13
	2	183 (55)	203 (72)	20
	3	183 (60)	204 (69)	21
	4	184 (66)	203 (75)	19

Standard deviations are indicated in bracket
* indicates significant at 0.05 level.

B. Analysis of variance summary tables for mean and standard deviation scores of decision time for the ten subjects in the second experiment.

(a) Means

Source	SS	df	MS	F	p
Between	966.60	4	241.65	0.04	n.s.
Within	305015.90	45	6778.13		
Total	305982.50	49			

(b) Standard Deviations

Source	SS	df	MS	F	p
Between	575.52	4	143.88	0.37	n.s.
Within	17300.00	45	384.44		
Total	17875.52	49			

C. Analysis of variance summary tables for mean and standard deviation scores of movement time for the ten subjects in the second experiment.

(a) Means

Source	SS	df	MS	F	p
Between	21.92	4	5.48	.00	n.s.
Within	240319.60	45	5340.44		
Total	240341.52	49			

(b) Standard Deviations

Source	SS	df	MS	F	p
Between	329.72	4	82.43	0.53	n.s.
Within	6948.70	45	154.42		
Total	7278.42	49			

APPENDIX VII

A. Analysis of variance summary table for scores of physical work capacity (PWC 170) for non handicapped, retarded and psychiatrically disturbed subjects.

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	657463.34	2	328731.67	13.74	<0.01
Sex	1315720.4	1	1315720.4	55.00	<0.01
Interaction	89563.334	2	44781.667	1.87	n.s.
Within cell	1291877.5	54	23923.658		
Total	3354624.6	59			

B. Post hoc comparisons between mean values of PWC (170) for non handicapped, retarded and psychiatrically disturbed male subjects following analysis of variance above.

	1 Non handicapped	2 Retarded	3 Psychiatrically Disturbed
Mean	1077	734	843
S.D.	110.28	122.70	183.40

Comparisons of means		Differences	t value	df	p
1	2	343	6.57467	18	<0.01
1	3	234	3.45777	18	<0.01
2	3	109	1.56208	18	n.s.

C. Post hoc comparisons between mean values of PWC (170) for non handicapped, retarded and psychiatrically disturbed female subjects following analysis of variance above.

	1 Non handicapped	2 Retarded	3 Psychiatrically Disturbed
Mean	681	526	560
S.D.	138.99	151.06	201.38

Comparisons of means	Differences	t values	df	p
1 - 2	155	2.3878	18	<0.05
1 - 3	121	1.5638	18	n.s.
2 - 3	34	0.4271	18	n.s.

APPENDIX VIII

A. Analysis of variance summary table for scores of PWC (170) per kilogram body weight for non handicapped, retarded and psychiatrically disturbed subjects.

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	49.6653	2	24.8327	3.29	<0.05
Sex	204.7954	1	204.7954	27.13	<0.01
Interaction	0.5013	2	0.2507	0.03	n.s.
Within cell	407.7109	54	7.5502		
Total	662.6729	59			

B. Post hoc comparisons between mean values of PWC (170) per kilogram body weight for non handicapped, retarded and psychiatrically disturbed male subjects.

	1 Non handicapped	2 Retarded	3 Psychiatrically Disturbed
Mean	14.15	12.35	12.76
S.D.	1.94	3.53	3.22

Comparison of means	Differences	t	df	p
1 - 2	1.8	1.4132	18	n.s.
1 - 3	1.39	1.1693	18	n.s.
2 - 3	.41	0.2714	18	n.s.

C. Post hoc comparisons between mean values of PWC (170) per kilogram body weight for non handicapped, retarded and psychiatrically disturbed female subjects.

	1 Non handicapped	2 Retarded	3 Psychiatrically Disturbed
Mean	10.77	8.90	8.88
S.D.	1.79	3.04	2.52

Comparison of means	Differences	t	df	p
1 - 2	1.87	1.6762	18	n.s.
1 - 3	1.89	1.9336	18	<0.05
2 - 3	0.02	0.0160	18	n.s.

APPENDIX IX

A. Analysis of variance summary table for scores of maximum oxygen intake (MvO_2) per kilogram body weight for non handicapped, retarded and psychiatrically disturbed subjects.

Summary of Analysis of Variance

Source	SS	df	MS	F	p
Groups	704.4333	2	352.2167	3.93	<0.05
Sex	952.0167	1	952.0167	10.62	<0.01
Interaction	29.4333	2	14.7167	0.16	n.s.
Within cell	4842.3000	54	89.6722		
Total	6528.1833	59			

B. Post hoc comparisons between mean values of MvO_2 per kilogram body weight for non handicapped, retarded and psychiatrically disturbed male subjects.

	1 Non handicapped	2 Retarded	3 Psychiatrically Disturbed
Mean	45.4	40.2	38.7
S.D.	9.80	11.45	11.33

Comparison of means	Differences	t	df	p
1 - 2	5.2	1.0911	18	n.s.
1 - 3	6.7	1.4143	18	n.s.
2 - 3	1.5	0.2945	18	n.s.

C. Post hoc comparisons between mean values of MvO_2 per kilogram body weight for non handicapped, retarded and psychiatrically disturbed female subjects.

	1 Non handicapped	2 Retarded	3 Psychiatrically Disturbed
Mean	38.7	32.5	28.9
S.D.	6.23	9.34	7.43

Comparison of means	Differences	t	df	p
1 - 2	6.2	1.7463	18	<0.05
1 - 3	9.8	3.1961	18	<0.01
2 - 3	3.6	0.9539	18	n.s.

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GLOSSARY OF TERMS

RECREATION	-	an activity which a person chooses to be involved in, and which can be regarded as a diversion, and thus complementary to the normal working activities. The value attributed to a recreative activity is usually indicated by its reciprocity or the level of involvement of the participants.
PHYSICAL RECREATION	-	an activity involving gross and relatively vigorous body movements which an individual chooses to do during unobligated time, and which is done for its own intrinsic worth.
PHYSICAL FITNESS	-	a measure of the efficiency and capacity of an individual to perform physical work.
MENTALLY RETARDED	-	a level of intellectual functioning that is significantly below average, that is usually apparent early in life, and that is characterised by learning and behavioural deficiencies over a wide range of abilities.
MENTALLY DISTURBED	-	a wide variety of clinical conditions including both neurotic and psychotic depressive states, schizophrenic reactions, paranoid tendencies and a diversity of personality inadequacies. All persons so described had spent some time within a clinical institution.