The prediction of anaerobic power.

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C O N T E N T S

S U M M A R Y

The use of performance testing in physical education tends to be based on subjective divisions of human function into qualities such as strength, speed, agility etc. All these qualities depend on the same metabolic process and the intention of this study was to determine whether it was possible to predict the capacity of this metabolic process from performance tests which are widely used in physical education.

Anaerobic power and relative anaerobic power was measured in 88 female physical education students and data on 50 metre run time, 50 metre shuttle run time, basketball throw, vertical jump and anthropometric measurements was collected from the same sample. A further group of subjects was used to determine the effect of motivation on the power test results.

The S.C.S.S. computer package was used to determine the following regression equations:

anaerobic power = 1.202 (weight) Kg.
- 5.198 (50 metre run time) sec.
+ 40.526 (vertical jump distance) m.
+ 40.477.

relative anaerobic power = .562 (vertical jump distance) m.
- .081 (50 metre run time) sec.
- .018 (50 metre shuttle run time) sec.
+ 2.152.

There was no evidence that motivation substantially affected performance on the power test.

INTRODUCTION

The concept of physical education has been widely discussed by a variety of authors (Andrews 1979 Arnold 1968) however different authors tend to choose the same elements which together make up this concept. These elements are listed by Carlisle (1977) as:

personal experiential ; which covers the aspect of the development by the individual of awareness of himself and of others.

conditioning ; the physiological and psychological element within physical education.

technical ; the skill in physical activities which are involved in physical education.

performance ; the experience of activities for their own sake

appreciation - study, a knowledge of the historical, cultural and scientific significance of physical activity and physical education

Taylor (1976) in a general discussion on the meaning of evaluation concludes that it contains two distinct strands which are given the overall names of 'judgement' and 'measurement'. The judgement aspect involves the formation of an opinion on the worth of qualities which are quantified by the measurement process. The relevance of evaluation to physical education has been clarified by a number of authors (Johnson and Nelson 1974, Mathews 1978, Almond 1977). These authors have tended to produce similar ideas of the purposes of evaluation in physical education phrased in different ways and these are summarized by Phillips and Hornak (1979) as:

placement - the use of evaluation to match individual ability or interest to different activities.

diagnosis of learning problems

progress during instruction

achievement after instruction

determination of improvement

motivation of students through feedback

assessment of teaching

assessment of curriculum

prediction of future success

development of norms.

These ideas on the nature of the components of the concept of physical education and the purposes of evaluation are related together in a diagramatic manner by Phillips and Hornak (1979):

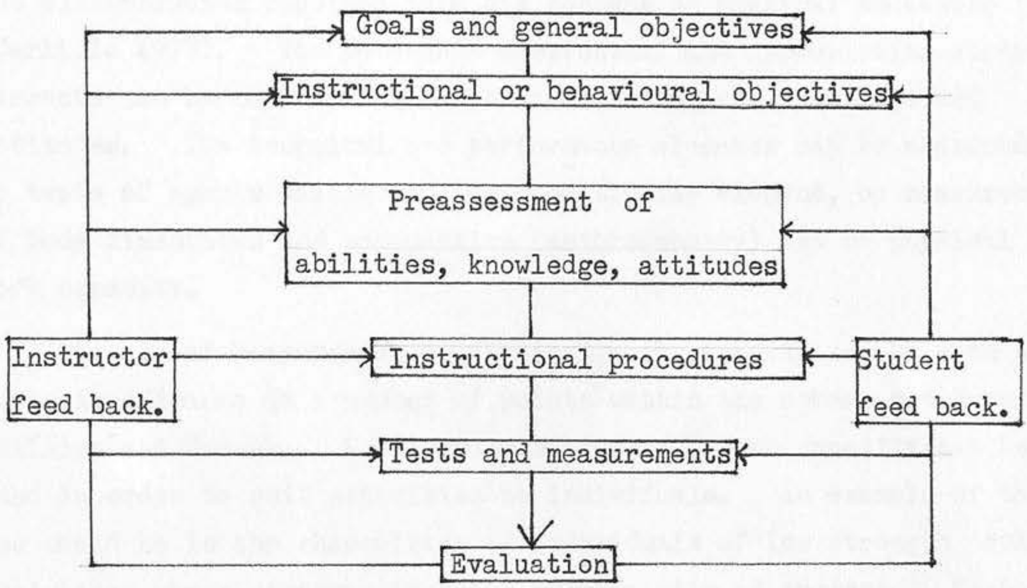


Figure 1. Diagram of relationship between objectives, teaching and evaluation (Phillips and Hornak 1979).

The intention of this diagram is to suggest that the elements which make up the concept of physical education can be rendered as general objectives and these, in turn, as specific behavioural objectives. Use can then be made of measurement in order to assess qualities of the individual before starting a course of teaching. Referring back to the ideas of Phillips and Hornak on the purposes of measurement in physical education, preassessment would be related to placement, determination of improvement, prediction of future success and the development of norms.

After the instructional process has taken place, further measurement can be carried out with a view to determining progress and overall improvement, motivating the participants and assessing both the teaching and the material which was taught.

Evaluation as described by Taylor (1976) would then involve not only the making of measurements but also some sort of judgement of, for example the success or failure of the teaching programme. This, of necessity, must be related to the initially stated behavioural objectives. The results of evaluation can be used to modify any or all of the preceding stages in the sequence.

The qualities which can be usefully measured are related to the elementswhich together form the concept of physical education (Carlisle 1977). The personal- experential and appreciation-study elements can be measured using instruments to test knowledge and attitudes. The technical and performance elements can be measured by tests of sports skills and the conditioning element, by measurement of body dimentions and composition (anthropometry) and of physical work capacity.

The use of measurement of physical work capacity can be seen to have significance at a number of points within the scheme set down by Phillips and Hornak. A knowledge of physical work capacity can be used in order to suit activities to individuals. An example of this use would be in the channelling of individuals of low strength towards activities where strength is not a prerequisite of success. Further uses of measurement of work capacity could be in measuring progress during instruction, motivating students, the prediction of future success and the development of norms.

Use of measurement of work capacity can also be made in the selection of individuals who have the potential for high level performance.

The measurement instruments which have been widely used to assess work capacity in physical education in the past have tended to be based on performance of specified activities in the assumption that measurement of this performance represents the ability of an individual in terms of a specified quality. The qualities which can be measured by this approach include strength, agility, flexibility, cardiovascular endurance, balance and co-ordination.

Within the area of strength, Fleishman (1964) has identified a number of sub-components:

Explosive strength - the ability to exert a maximum of strength in a brief movement. i.e. one maximal muscle contraction.

Dynamic strength - strength which is exerted over a number of seperate muscle contractions.

Static strength - strength exerted over a single maximal muscle contraction which requires no limb movement.

Muscular endurance which in Fleishman's terms appears similar to the definition of dynamic strength but is described as involving maximal effort over a period of time and consequently, an ability to resist fatigue.

The importance of a further factor referred to as speed is discounted by Fleishman but supported by Simons (1966) who has identified it by using factor analysis.

This classification of strength is satisfactory from a performance point of view but requires greater refinement if it is to be related to the internal chemical processes which produce the external work. The advantage of this approach is that it allows the measurement of work output rather than the measurement of a score based on the number of repetitions of an activity.

The chemical processes which produce the energy which allows for muscle contraction can be classified into three types (Margaria 1976).

The first of these can be summarized as follows:

glycogen + oxygen ⟶ carbon dioxide + water + energy.

The glycogen used in this process is stored in the muscle and the energy rleased has to undergo further transformation before it can be used to produce muscle contraction. The use of oxygen is significant since under normal circumstances the oxygen supply limits the rate of energy production from this system. This process is usually described as aerobic energy production.

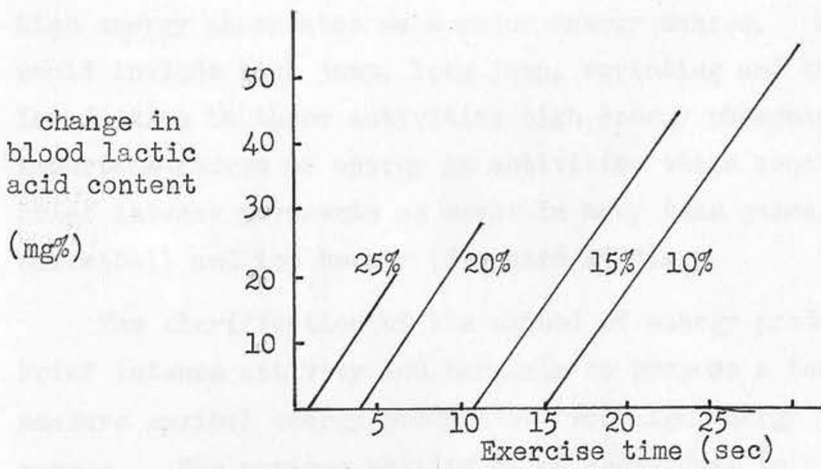
The second process which produces energy is usually described as anaerobic since it does not involve the use of oxygen. This process, called glycolysis, can be summarized as:

Glycogen ⟶ lactic acid + energy.

The third process which is also described as anaerobic, since it does not require oxygen, is based on the presence in the muscle of high energy phosphates. The reactions which occur to bring about the release of energy from these phosphates can be summarized as:

high energy phosphate → low energy phosphate + phosphate + energy

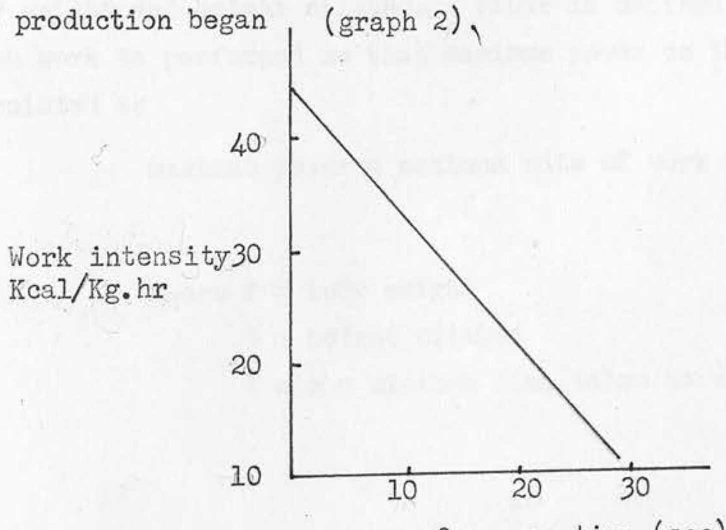
Margaria (1964) carried out work to identify which of these processes contribute to high intensity work of short duration. The work involved treadmill running at a variety of inclines. Measurement was made of blood lactic acid which gives an indication of the engagement of glycolysis. The results, when plotted indicated the period of activity which was, in energy terms, supported by processes other than glycolysis. This was shown by the intersection of the plotted line with the y axis on graph 1.



Graph 1 Lactic acid production during running at different inclines (Margaria 1964)

The time before engagement of glycolysis amounted to a period of 15 sec when running at a 10 % incline.

This data was re-plotted to show the graph of energy equivalent of work at the different inclines against the time before lactic acid production began (graph 2).



Graph 2 Performance time at varying work intensity (Margaria 1964).

The straight line crossed the x axis at 45 K cal/ Kg.hr. which represents the maximum power which can be produced during the pre-glycolytic phase.

Aerobic energy production is a sluggish process and does not make an appreciable contribution to energy production during the first moments of physical work thus it can be concluded that work during the pre-glycolytic phase is supported by breakdown of high energy phosphate alone and that in the subjects used in the study this amounted to a maximum of 45 K cal./Kg.hr.

Since the breakdown of high energy phosphates supports activity of maximal or near maximal intensity for up to 15 seconds it follows that any activity which is completed within this time relies on these high energy phosphates as a major energy source. Such activities would include high jump, long jump, sprinting and throwing etc. In addition to these activities high energy phosphates are also an important source of energy in activities which require a number of brief intense movements as occur in many team games, noteably basketball and ice hockey (Shephard 1978).

The clarification of the method of energy production during brief intense activity led Margaria to propose a test which would measure maximal energy production from high energy phosphates in the muscle. The maximum ability of an individual to produce energy from these sources is referred to as anaerobic power. The test was constructed on the basis that in running, after an initial acceleration phase, when maximum effort is exerted, a constant speed is maintained for up to 5 seconds. The external work is measured by carrying out the running on a staircase and calculating work as the product of body weight and height climbed. Power is defined as the rate at which work is performed so that maximum power on the test can be calculated as

$$\text{maximum power} = \text{maximum rate of work} = \frac{F \times d}{t\ \text{min}}$$

where F = body weight

d = height climbed

t min = minimum time taken to climb the stairs.

Work on this test by Margaria (1966) produced results for anaerobic power (i.e. the maximum rate of work which can be supported by the high energy phosphate in muscle) which correspond to those produced in graph 2, which supports this test as a valid measure of anaerobic power.

The test was developed further by Kalamen (1968) who found that a 6 metre run-up to the foot of the stairs ensured that the initial acceleration phase had been completed before the stair climbing began.

The equation:

$$\text{power} = \frac{F \times d}{t}$$

used in calculating anaerobic power from test performance, results is an expression of power in units of Kgm/sec. When power is expressed in this way individuals having a high body weight have an advantage in that the component 'F' of the equation is large and hence the anaerobic power tends also to be large. However in terms of the activities which are carried out using high energy phosphate as a major energy source (throwing, sprinting etc.) the body weight of the individual, whilst having some importance in mechanical terms, is not relevant to the efficiency of the chemical processes which are occurring in the muscle fibres and which a test of anaerobic power sets out to measure. This problem was overcome in the original work on this test (Margaria 1966) by the calculation of results in terms of anaerobic power relative to body weight.

$$\text{relative anaerobic power} = \frac{\text{power}}{F}$$

The units in which relative anaerobic power is expressed are Kg.m./Kg.sec. The values produced by such calculation are numerically identical to the vertical velocity in m/sec.

Subsequent authors (Kalamen 1968, Mathews and Fox 1976) have used the absolute anaerobic power measurement calculated from F x d/t. In this study, results will be calculated and data analysis carried out using both (absolute) anaerobic power and relative anaerobic power.

In view of the variety of different sub-components which can be identified as making up the quality of strength and the difficulty in separating some of these sub-components from one another it may be argued that a more unified approach may be more profitable. A test such as that described by Margoria (1964) has the advantage that it sets out to measure the efficiency of a process which underpins all the different sub components of strength and speed performance. A further advantage of the Margaria test is that it measures a general quality which is of importance in specific activities (e.g. high jump) without relying on the individual having previously mastered the technique necessary to carry out the activity.

This approach has been taken in some cases where attempts have been made to obtain an estimate of anaerobic power from some of the tests described by Fleishman. These however have concentrated on vertical jump (Mathews and Fox 1976) or on 50 metre run time (Fox and Mathews 1974) neither of which are ideal as means of assessing anaerobic power, the former because it relies on a single maximal effort by the individual therefore making no allowance for the acceleration phase recognised by Margaria (1964) and the latter because performance has a duration in excess of 5 seconds and thus the power output is sub maximal during the last phase of the run. In addition because 50 m run is carried out on a level track it is difficult to measure the external work which has been performed.

In this study, the intention was to investigate vertical jump and 50 metre run time with a view to constructing . regression equations which would be more successful as predictors of anaerobic and relative anaerobic power when combined than when the predictor variables were used on their own. In addition to these variables 50 metre shuttle run and basket ball throw were also included as predictor variables. 50 metre shuttle run has the advantage over 50 metre run in practical terms in that it is a test which can be carried out indoors and thus is not as susceptible to environmental influence as 50 metre run test. It does however include an element of agility which is not included in 50 metre run and which does not make any contribution to an individual's power output. Basketball throw was included in order to see if the measurement of power was assisted by taking into account performance in muscle groups different to those responsible for running and jumping. Since anaerobic and relative anaerobic power are calculated from the reciprocal of time, 50 metre shuttle run performance and 50 metre run performance were both expressed in terms of time and speed (i.e. the raw data and its reciprocal). Scale changes (square and square roots) of vertical jump distance and basket ball throw were also included to find whether these gave improved prediction over the corresponding raw data.

Leg length has been shown by Withers et al (1979) to have some effect on anaerobic power (significant in male subjects and insignificant - $P = 0.07$ - in female subjects where 24 female and 24 male subjects were used) and, with other anthropometric measurements was included as a predictor variable in this study.

A further problem which is not in general considered by discussions of test batteries is that of motivation in relationship to performance on the tests. This problem is also largely neglected by Margaria (1966) in considering the limitations of the stair test. The only reference to motivation being that, since the test is not complicated and is quickly performed, it is accepted well by the testee. In addition the effect of practice on the test is also not considered. Kalamen (1968) investigated this by measuring performance over 15 attempts on the stair test by 23 subjects. Results are not presented so it is impossible to draw conclusions on the possible effect of practice.

In this study the effects of motivation and learning on performance were investigated by repeating the measures on the stair test. The pattern which would emerge from these repeated measures could be expected to show as an increase in performance during the series of tests if learning was taking place and consistent or declining results if subjects were poorly motivated. A second approach was made to the problem of motivation by using a subsidiary group of subjects who were not motivated by the tester to perform maximally and whose results would be compared with subjects who were motivated.

The overall aim of the experiment was the production of two regression equations which would allow for the best possible prediction of anaerobic and relative anaerobic power.

METHOD

(1) Design of experiment.

The main part of the study was carried out on 88 female physical education students with an average age of 19.6 years ($\sigma = 0.6$) at the start of the study. The subjects chosen were all members of one year group although out of the total number in the year group (108) a total of 20 students defected from the study. The subsidiary part of the experiment which was intended to detect the effect of motivation on the power measures was carried out using a group of 14 female physical education students with an average age of 20.1 years ($\sigma = 0.7$) who were selected from a different year group to those subjects in the main part of the experiment.

The intention of the main part of the experiment was, to collect data in order to arrive at regression equations which would permit the prediction of anaerobic power and relative anaerobic power. These two variables were the dependant variables used in the construction of the regression equations. Other calculated and measured variables were used as predictor variables in these equations.

The variables measured in the data collection were : time on the stair test, reach, vertical jump height, basketball throw distance, 50 metre run time, 50 metre shuttle run time, age, arm length, sitting height, height and weight. These variables were measured over a period of 10 weeks, each subject attending four measurement sessions consisting of:

session (a), time on stair test.
" (b), height, weight, sitting height
arm length, vertical jump.
" (c), basketball throw, 50m shuttle run
" (d), 50 m. run.

The variables time on stair test, vertical jump and basketball throw were measured six times for each subject. The number of trials used was a compromise between the desirability of obtaining sufficient repetitions to ensure maximum performance and the effect on subject cooperation of requiring a large number of repititions. In the case of the time measurement, the test was carried out by groups of subjects varying in number from 2 to 5, each subject making seperate attempts on the test in rotation with other members of the group. Before each attempt the subject was encouraged to perform as well as possible and reminded of the result of the previous attempt. This pattern was also followed with vertical jump measurement and the basketball throw although in these tests rotation with other subjects did not take place.

In the subsidiary group, performance in the stair test was carried out singly and other subjects were excluded from the room where the test took place. The subject was not told the results of the test until after the last attempt. Adequate rest was allowed between each attempt, the duration being dependent on the subjective experience of the testee.

The statistical analysis was carried out using the S.C.S.S. computer package (Nie and Hull, 1978). This was used to calculate the dependant variables as:

anaerobic power = $\dfrac{\text{weight x ht. climbed}}{\text{time on stair test.}}$

relative anaerobic power = $\dfrac{\text{height climbed x weight}}{\text{time on stair test x weight.}}$

and also a number of computed independant variables

vertical jump distance = vertical jump height - reach

leg length = height - sitting height

square of basket ball throw

square root of basket ball throw

square of vertical jump distance

square root of vertical jump distance

reciprocal of 50 m. run time

reciprocal of 50 m. shuttle run time.

In the calculation of all variables where repeated measures were made, the best value for each subject was used.

The S.C.S.S. package was also used to carry out univariate statistical analyses, correlational analysis (Pearson product moment) and stepwise multiple regression analysis. The criterion used for inclusion of a variable in the stepwise multiple regression equations were that the significance of the F value* for the change in the squared multiple correlation coefficient should be less than .05 and that the tolerance+ should be greater than .01. These criteria ensured that any variable entering the equation made a significant contribution to the percentage of variance which the regression formula explained (R^2) and that it did not have a near perfect multiple correlation with the variables already in the equation. The use of stepwise analysis ensured that the variables in the equation which failed to meet the entry criteria as a result of a new variable entering the equation were excluded.

$$* \quad F = \frac{r^2_y}{(1 - R^2_y) / (N - k-1)}$$

Where r^2_y = change in squared multiple correlation coefficient caused by the inclusion of the variable

R^2_y = squared multiple corrleation coefficient

k = number of variables included

N = sample size.

(Nie, Hull et al 1975)

+ Tolerance is a measure of the variance of the dependent variable which the variable to be entered into the regression equation explains and which is not common to the variables already in the equation. It is calculated as:

$$1 - R^2_{y.\,12....i..k}$$

Where $R^2_{y.\,12..i..k}$ = squared multiple correlation coefficient between the variable to be entered and the variables already in the equation.

The regression analyses were carried out using anaerobic power and relative anaerobic power as dependant variables and the following list of predictor variables:

performance variables:	basketball throw
	square of basketball throw
	square root of basketball throw
	vertical jump distance
	square of vertical jump distance
	square root of vertical jump distance
	50 m run time
	reciprocal of 50m. run time
	50 m shuttle run time
	reciprocal of 50 m shuttle run time.
anthropometric variables:	age
	arm length
	sitting height
	height
	weight

Only data from the 73 subjects whose records did not contain missing values was used in the correlation and regression analyses.

In the analysis of the data collected from the subsidiary group, the subjects were matched with individuals from the main group. Matching was carried out initially on the basis of the pattern of the results measured over the six attempts on the stair test and thereafter subjects were matched on the basis of weight (in the case of anaerobic power) and leg length (in the case of relative anaerobic power) since these predictor variables were found to have the best correlation with the appropriate dependant variable. The significance of the difference between the two groups was tested using a 't' test for correlated data.

(ii) Measurement techniques.

The following measurements or procedures were used to collect the raw data:

(a) Margaria - Kalamen power test

(b) basketball throw

(c) vertical jump

(d) 50 metre run

(e) 50 metre shuttle run

(f) arm length

(g) sitting height

(h) height

(i) weight.

(a) Margaria - Kalamen power test.

This test was carried out in the manner described by Mathews and Fox (1976).

A flight of 14 stairs was used in front of which was an open space extending for 6.5 m from the foot of the stairs. There was an open space of 2m. extending from the head of the stairs.

Photoelectric cells and light sources supported by retort stands were placed on the second and tenth steps. These were connected to a digital timer (Griffin) capable of being read to 0.001 sec (accuracy $\mp$ .5%) in such a way that the breaking of the light beam on the second step started the timer and the breaking of the light beam on the tenth step stopped the timer. The vertical distance between the light beams was 1.48m. and the stairs were set at gradient of 36.4%.

Before taking part in the test the procedure was described to each subject and a demonstration of the technique was given. The subject was instructed to stand 6 m. in front of the foot of the stairs and to run up the stairs, two steps at a time as fast as possible and to continue to the top of the stairs (Subjects were also cautioned to lift their feet clear of the stair risers in view of the possibility of tripping). Before starting it was explained that this was a test of maximum power and that each subject would be allowed 6 attempts.

With the subsidiary group of 14 subjects this was the last instruction given, however for the main group of subjects the results were fed back to each testee and she was given further encouragement prior to each attempt on the test. This group of subjects carried out the 6 attempts in the test in rotation with other subjects.

The anaerobic power (Kg m /sec) of each subject was calculated as the maximum rate of work achieved over the six attempts.

$$\text{anaerobic power} = \text{max. rate of work} = \frac{F \times d}{t\ min}$$

where F = body weight (Kg)

d = height climbed = 1.48m

t min = minimum time on stair test (sec).

Relative anaerobic power (Kgm /Kg sec) was also calculated from the maximum rate of work achieved.

$$\text{Relative anaerobic power} = \frac{F \times d}{t\ min \times F} = \frac{d}{t\ min}$$

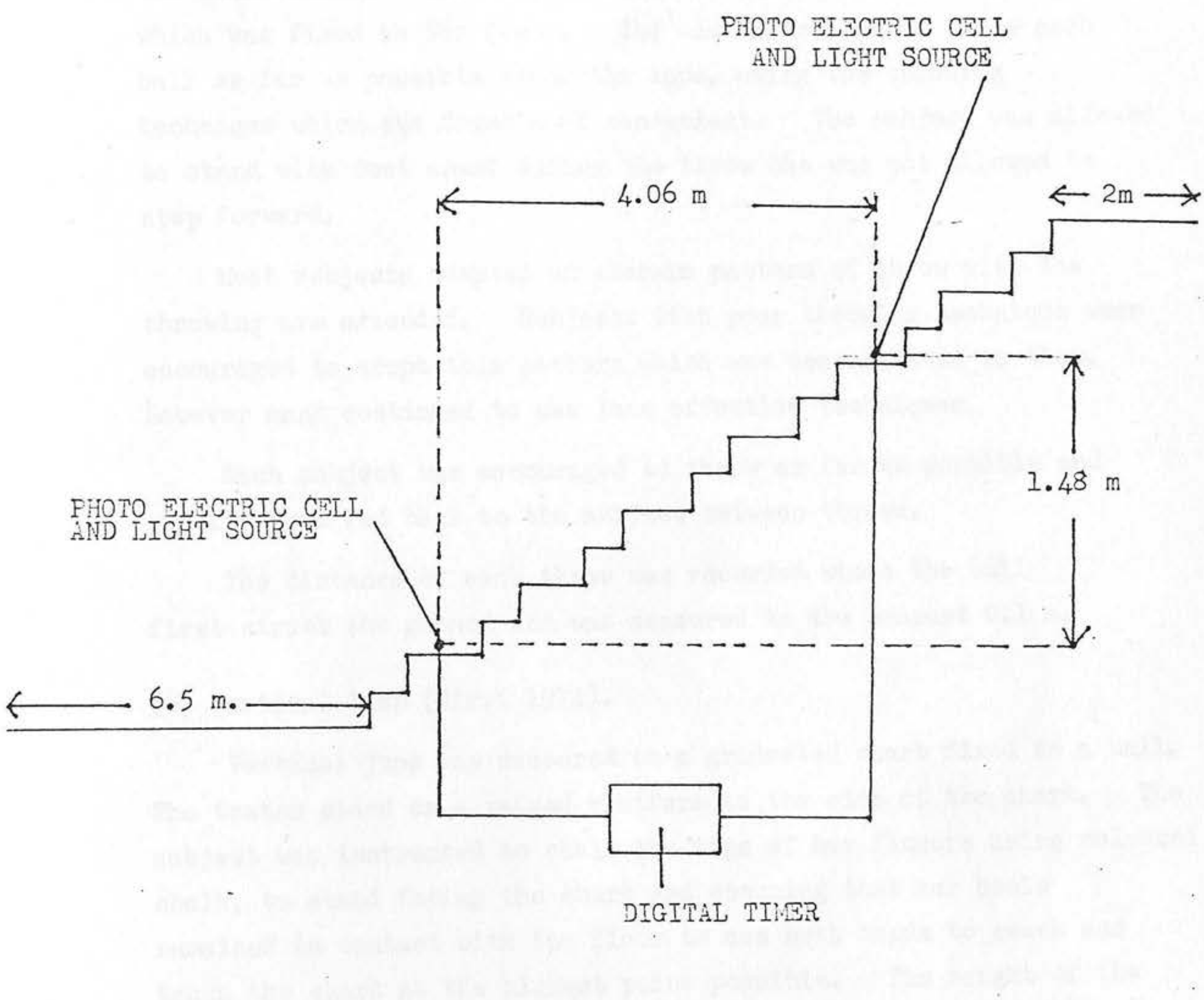


FIGURE 2 ARRANGEMENT OF TEST EQUIPMENT USED FOR MARGARIA KALAMEN POWER TEST

(b) basketball throw (Barrow and McGee 1971).

The basket ball throw test was carried out in a games hall using six basketballs. The subject stood at the end of a 30 m. tape which was fixed to the floor. She was instructed to throw each ball as far as possible along the tape, using the throwing technique which she found most convenient. The subject was allowed to stand with feet apart during the throw but was not allowed to step forward.

Most subjects adopted an overarm pattern of throw with the throwing arm extended. Subjects with poor throwing technique were encouraged to adopt this pattern which was demonstrated to them, however many continued to use less effective techniques.

Each subject was encouraged to throw as far as possible and results were fed back to the subject between throws.

The distance of each throw was recorded where the ball first struck the ground and was measured to the nearest 0.1 m.

(c) Vertical Jump (Simri 1974).

Vertical jump was measured on a graduated chart fixed to a wall. The tester stood on a raised platform to the side of the chart. The subject was instructed to chalk the tips of her fingers using coloured chalk, to stand facing the chart and ensuring that her heels remained in contact with the floor to use both hands to reach and touch the chart at the highest point possible. The height of the mark to the nearest 0.01 m. was recorded as 'reach'. The subject was then instructed to stand sideways (left or right according to choice) and from a semi-squatting position to jump and touch the chart at the highest point possible with the arm closest to the chart. The position of the chalk mark made by the fingers was recorded to the nearest 0.01 m. The subject was allowed six attempts seperated by a recovery period determined by the subject herself.

Before starting each subject was encouraged to jump as high as possible and results were made known to the subject as they were collected.

The vertical jump distance was calculated by subtracting the height of the reach mark from the height of the jump mark the highest value from the six attempts being used in the data analysis.

(d) 50 metre run (Hunsicker 1976).

50 metre run was carried out on a 100 m. grass running track and was timed with a 10 second sweep stopwatch. Subjects wore ordinary training shoes without spikes.

Before the test the purpose was explained to the subject and she was instructed to cover the 50 metres as quickly as possible.

The tester stood at the finishing line and issued the command 'Ready' followed by 'Go' at which the subject started running. This was accompanied by downward movement of the arm. At the same moment the stopwatch was started. The stopwatch was stopped as the subject crossed the finishing line and the time taken was recorded to the nearest 0.1 sec.

(e) 50 m shuttle run.

The 50 m shuttle run was similar to the 40 m. shuttle run described by Hunsicker (1976).

Two parallel lengths of white adhesive tape were placed on the floor 10 m. apart. A block of wood measuring .065 x .065 x .130 m was placed outside the finishing line.

The subject started with her foot behind starting line carrying a second block of wood. The tester stood at the opposite line where the run was to finish.

The procedure of the test was that:

(a) subject ran to the finishing line, deposited the block she was carrying behind the line and picked up the block lying there.

(b) subject returned to the starting line and deposited the block behind it.

(c) subject ran back to the finishing line, picked up the block lying behind it.

(d) subject carried the block back to the starting line

(e) subject exchanged the block she was carrying for the block lying behind the starting line and ran to the finishing line where she deposited the block.

In all the subject covered the course five times. Before starting the procedure was explained and demonstrated to the subject and the subject was asked to cover the course in the shortest possible time. The tester issued the commands 'Ready' and 'Go' and the time to cover the course was measured to the nearest 0.1 sec. using a 10 second sweep stopwatch.

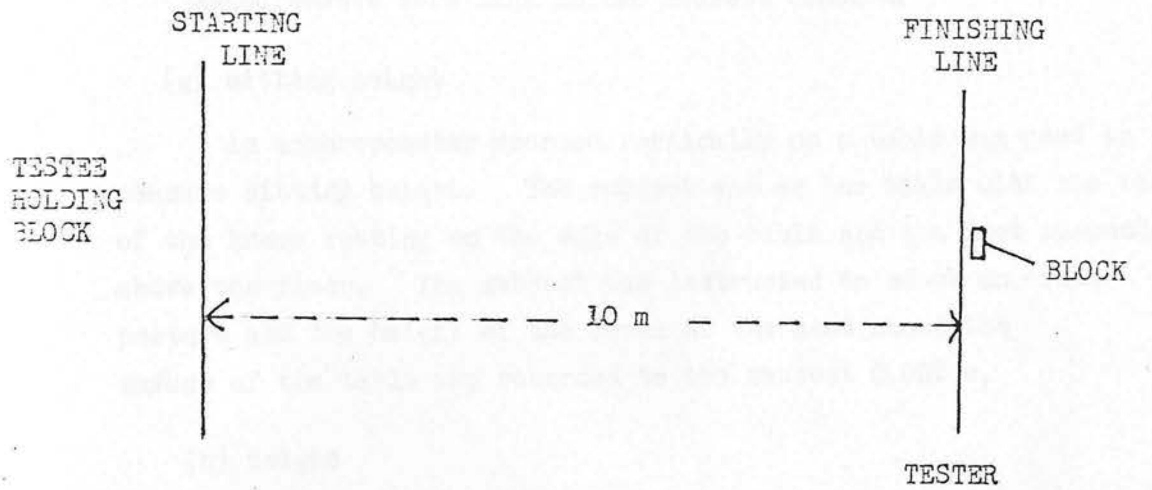


FIGURE 3 STARTING ARRANGEMENT FOR 50 METRE SHUTTLE RUN

The anthropometric measurements were made in the manner described by Weiner and Lourie (1969). All length measurements were made using Harpenden anthropometers.

(f) arm length

Arm length was measured on the left hand side of the body. The arm and fingers were extended downwards and the distance between the acromial process and the end of the longest finger was recorded.

Measurements were made to the nearest 0.001 m.

(g) sitting height

An anthropometer mounted vertically on a table was used to measure sitting height. The subject sat on the table with the back of the knees resting on the edge of the table and the feet suspended above the floor. The subject was instructed to adopt an erect posture and the height of the crown of the head above the surface of the table was recorded to the nearest 0.001 m.

(h) height

The subject was asked to remove her shoes and stand in front of a vertically mounted anthropometer. She adopted an extended posture whilst keeping her heels on the floor. Height was recorded to the nearest 0.001 m.

Leg length was calculated using the following equation:

Leg length = height - sitting height.

(g) weight

Weight was recorded after the subject had removed her shoes but was wearing otherwise normal light indoor clothing. No allowance was made for weight of clothing. Weight was measured using a long pillar beam scale (Avery) and was recorded to the nearest 0.1 Kg.

RESULTS

The results of tests where repeated measures were carried out all conform to a greater or lesser extent to the pattern shown most clearly in the graph of the group average of anaerobic power measured at each attempt (graph 4). It is worth noting that for relative anaerobic power, the pattern is the same as that for anaerobic power. This is due to the removal of the factor of weight in relative power which, in any one individual, is a constant over the six attempts measured. The pattern of anaerobic power measurement shows a gradual increase over the first five attempts with a relatively small rise between the fifth and sixth attempt.

This pattern is also followed in the anaerobic power measurement of the subsidiary, unmotivated group of subjects (graph 5) and in the series of measurements on basketball throw (graph 7) and vertical jump distance (graph 6) although in these cases there is an inflexion at the fourth or fifth measurement. In order to consider individual patterns over the six attempts on the Margaria Kalamen stair test, the results were split into four groups viz:

consistent group.

Subjects where there is little variation in power measured over the six attempts. For the purposes of this study the average and standard deviation of the six attempts made by each subject were obtained. 25% of the sample showing the lowest standard deviation were included in the consistent group.

inconsistent group.

Subjects in the group showed great variation in the anaerobic power measured at each attempt. The subjects who were allocated to this group consisted of 25% of the sample showing the highest standard deviation over the six attempts. Results showing a pronounced peaking or improving pattern were extracted from this group and included in the appropriate group.

peaking group.

The results included in this group were such that the maximum power measurement over the six attempts fell between the first and fifth attempts (inclusive).

improving group.

Here the maximum value for the power measurement was recorded in the last of the six attempts.

In a minority of cases the first attempt produced the highest power measurement (4 cases over the 79 recorded) and most subjects i.e. these in the inconsistent, peaking and improving groups showed considerable improvement over the value measured in the first attempt. The group of subjects who carried the test out without the motivational effects of feedback of results and verbal encouragement showed a similar sort of distribution of attempts as the main group of subjects. A greater proportion fell into the consistent pattern (54% when consistency is assessed using the same value for standard deviation of power measurement over the six attempts as used in assessing the consistency of the main group of subjects).

One subject in the unmotivated group recorded a peak measurement on the first attempt.

The pattern of attempts shown in basketball throw and vertical jump are presented in appendix 1. These have been grouped on the same basis as the anaerobic power measurements. In both cases a minority of subjects produced their maximum result at the first attempt (12 for basketball throw and 9 for vertical jump). In the case of basketball throw and vertical jump a substantially smaller proportion of the results fell into the improving pattern than was the case for the anaerobic power test, the appropriate proportions being, basketball throw 12%, vertical jump 14%, anaerobic power test 26%.

The unmotiviated subjects were matched with subjects from the main group on the basis of leg length (for relative anaerobic power) and weight (for anaerobic power). The average power measurements for these groups were:

relative anaerobic power (Kgm/Kg sec)	unmotivated group	1.37
	main group	1.41
anaerobic power (Kgm/sec)	unmotivated group	80.3
	main group	86.3

Using a t test for correlated data these differences were found to be insignificant ($p > .05$).

The data used in the construction of the regression equations is summarized on table 1. Distributions were near- normal, skewness varying from - .399 (50m shuttle run time) to 1.299 (square of basketball throw) and kurtosis from - .531 (age) to 2.780 (leg length).

The correlation analysis (Table 3) produced coefficients varying from .246 to .650 for correlations between the predictor variables and anaerobic power and from .041 to .463 for correlations between the predictor variables and relative anaerobic power. All predictor variables possessed significant correlation coefficients ($p < .05$) with anaerobic power. In the case of relative anaerobic power, all predictor variables except arm length, leg length, sitting height, height and weight showed significant correlation coefficients ($p < .05$).

Inter correlations between performance predictor variables varied from - .405 (between 50 m. run time and square root of vertical jump distance) to .083 (between reciprocal of shuttle run time and square root of basketball throw) this excludes intercorrelations between variables and their powers, roots or reciprocals.

Intercorrleations between anthropometric predictor variables were somewhat higher, varying from .432 (between weight and sitting height) to .842 (between leg length and height).

Within the performance predictor variables the running and jumping variables showed significant intercorrelations ($p < .05$) but insignificant correlations with basketball throw and its derived predictor variables. Correlations between performance predictor variables and anthropometric predictor variables tend not to be significant with the exception of vertical jump distance and its derived variables (square and square root of vertical jump distance) which show significant ($p < .05$) correlations with all anthropometric variables with the exception of weight. There are also significant correlations between 50m. run time and its reciprocal and height and between shuttle run time and its reciprocal and height.

Equations 1 - 4, 6 - 9 and 11 were produced by the regression analysis procedure but were considered to be unsuitable for use in prediction of anaerobic and relative anaerobic power. The basis of this unsuitability is considered in the discussion.

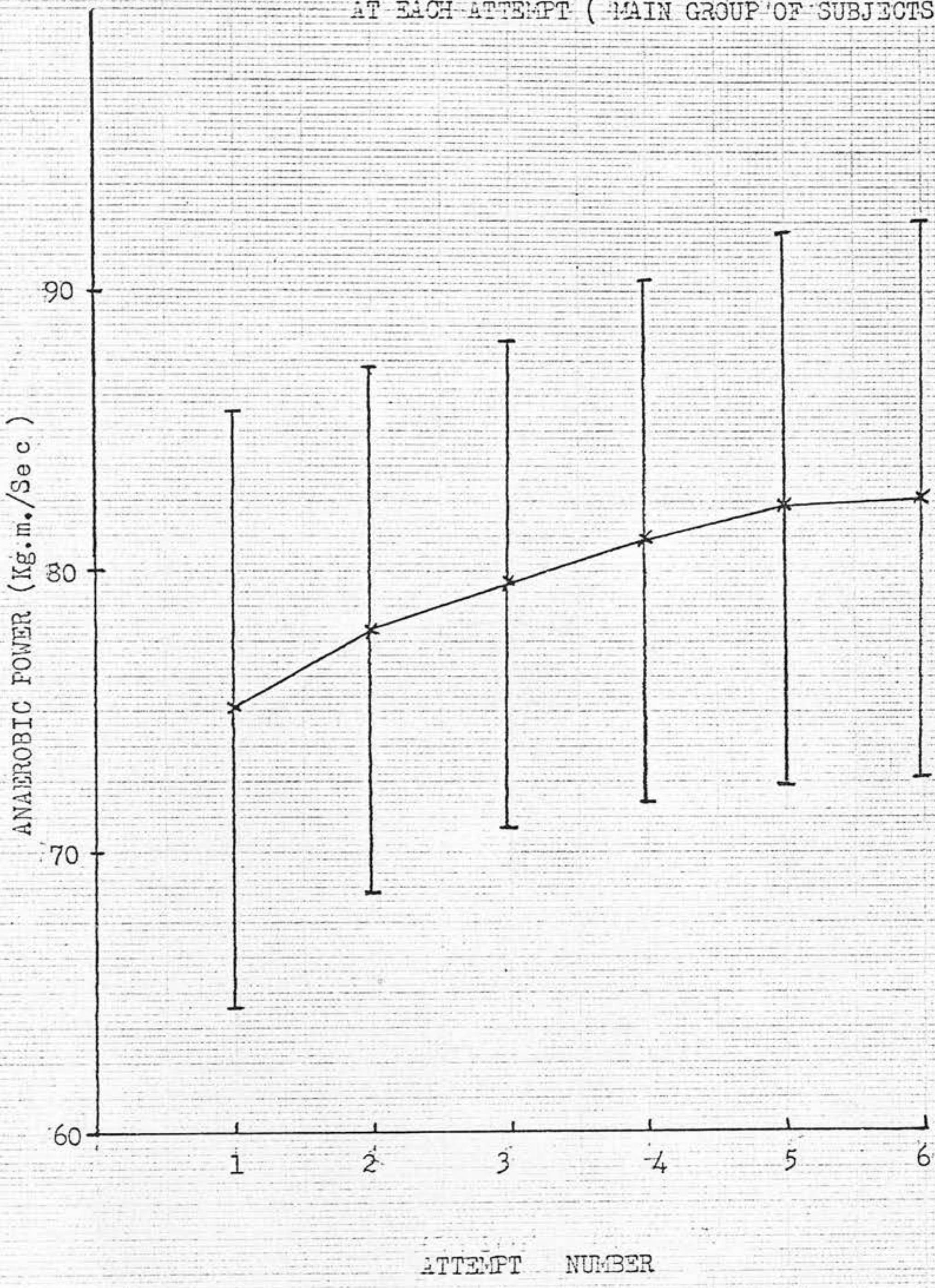
The standardized regression coefficients relating to these equations are presented in tables 4 and 5.

Equation 5 (Table 6) presented the most useful predictor of anaerobic power. The adjusted squared multiple * correlation coefficient for this equation was 0.623 and the single most potent contributor to the regression equation (assessed by the standardized regression coefficient - beta) was weight. The standard error associated with the equation was 6.16 K g.m./sec.

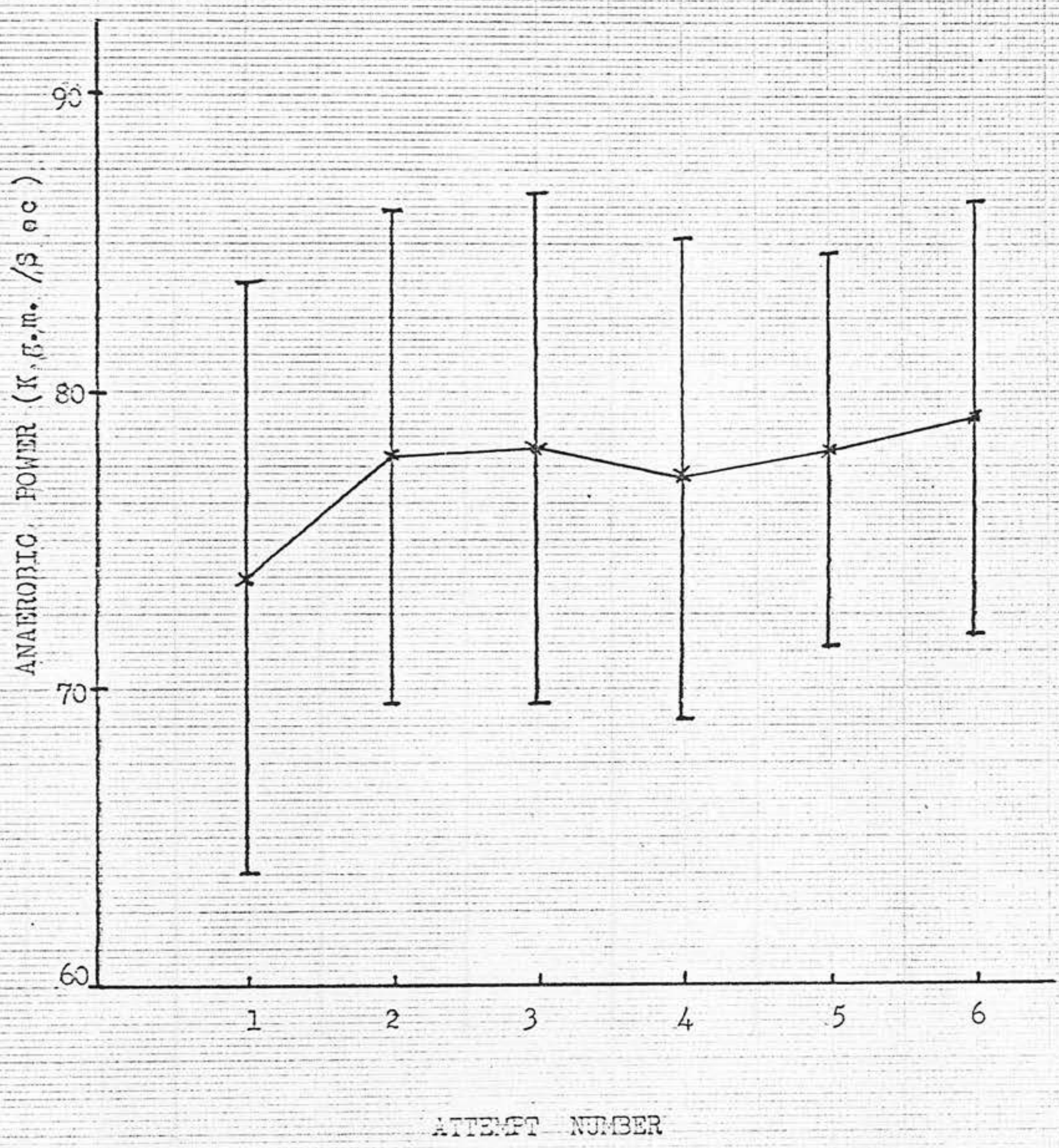
Equation 10 (Table 7) presented the most useful means of predicting relative anaerobic power. Here the adjusted squared multiple correlation coefficient was .359, 50 m. run time was the single most potent contributor to the regression equation (beta = -.378) and the standard error involved in the prediction was .104 K g.m./Kg. sec.

*The adjusted squared multiple correlation coefficient is a more conservative estimate of the explained variance than that provided by the squared multiple correlation coefficient. The adjustment takes account of the number of variables in the equation and the size of the sample (Nie, Hull et al 1975).

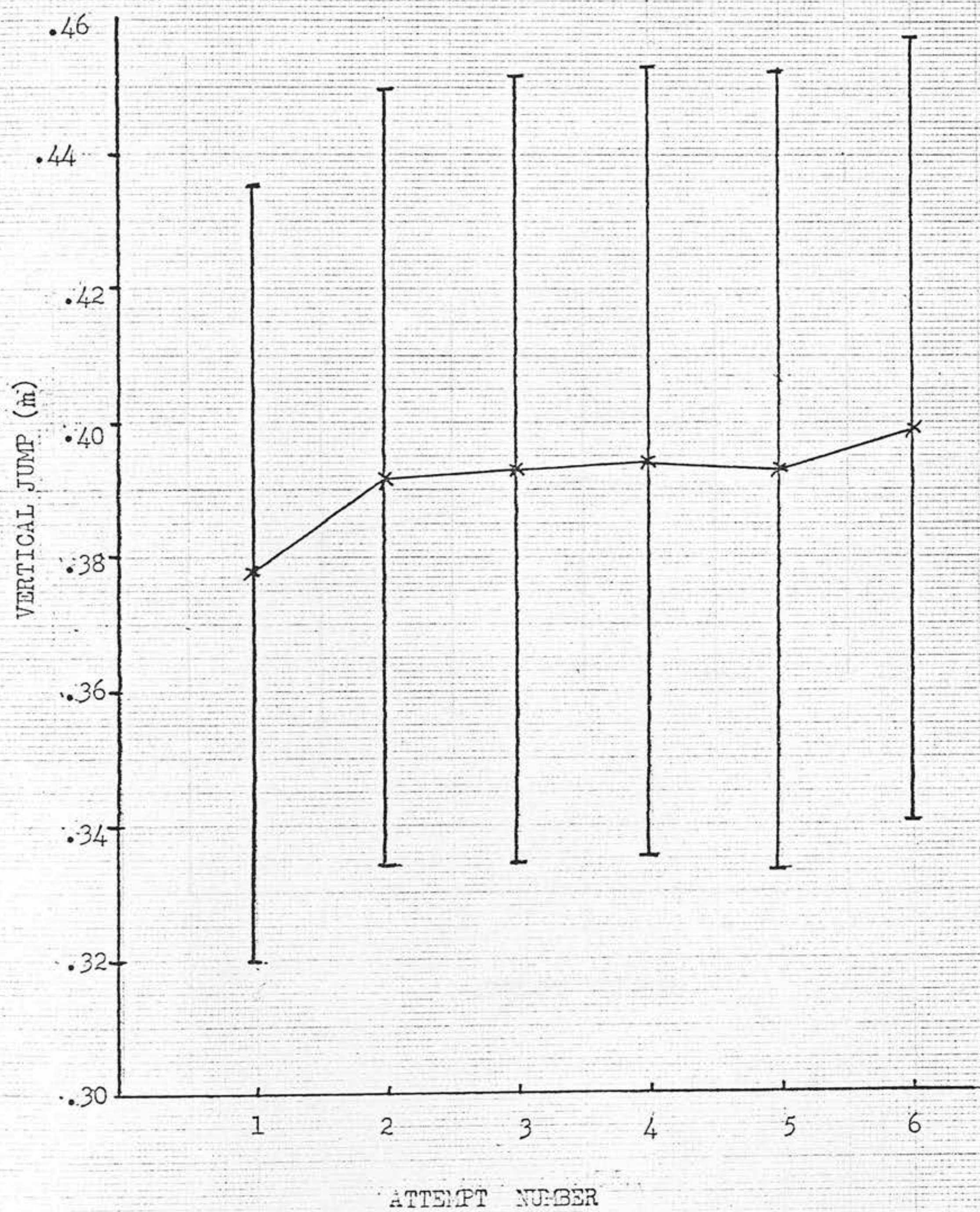
GRAPH 4. — MEANS AND STANDARD DEVIATIONS OF ANAEROBIC POWER MEASURED AT EACH ATTEMPT (MAIN GROUP OF SUBJECTS).



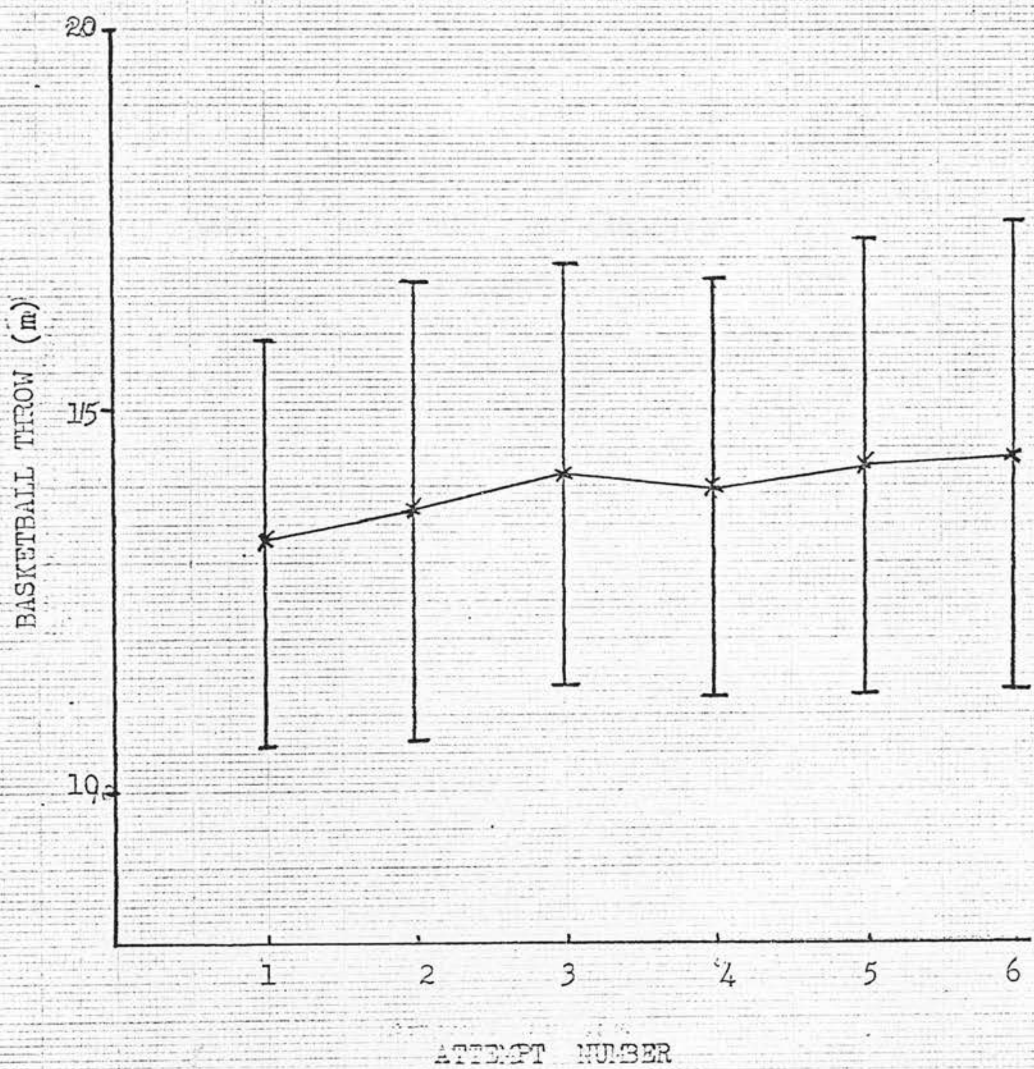
GRAPH 5 MEANS AND STANDARD DEVIATIONS OF ANAEROBIC POWER AT EACH ATTEMPT OF UNMOTIVATED GROUP.



GRAPH 6 MEANS AND STANDARD DEVIATIONS OF VERTICAL JUMP AT EACH ATTEMPT



GRAPH 7 MEANS AND STANDARD DEVIATIONS OF BASKETBALL THROW EACH ATTEMPT

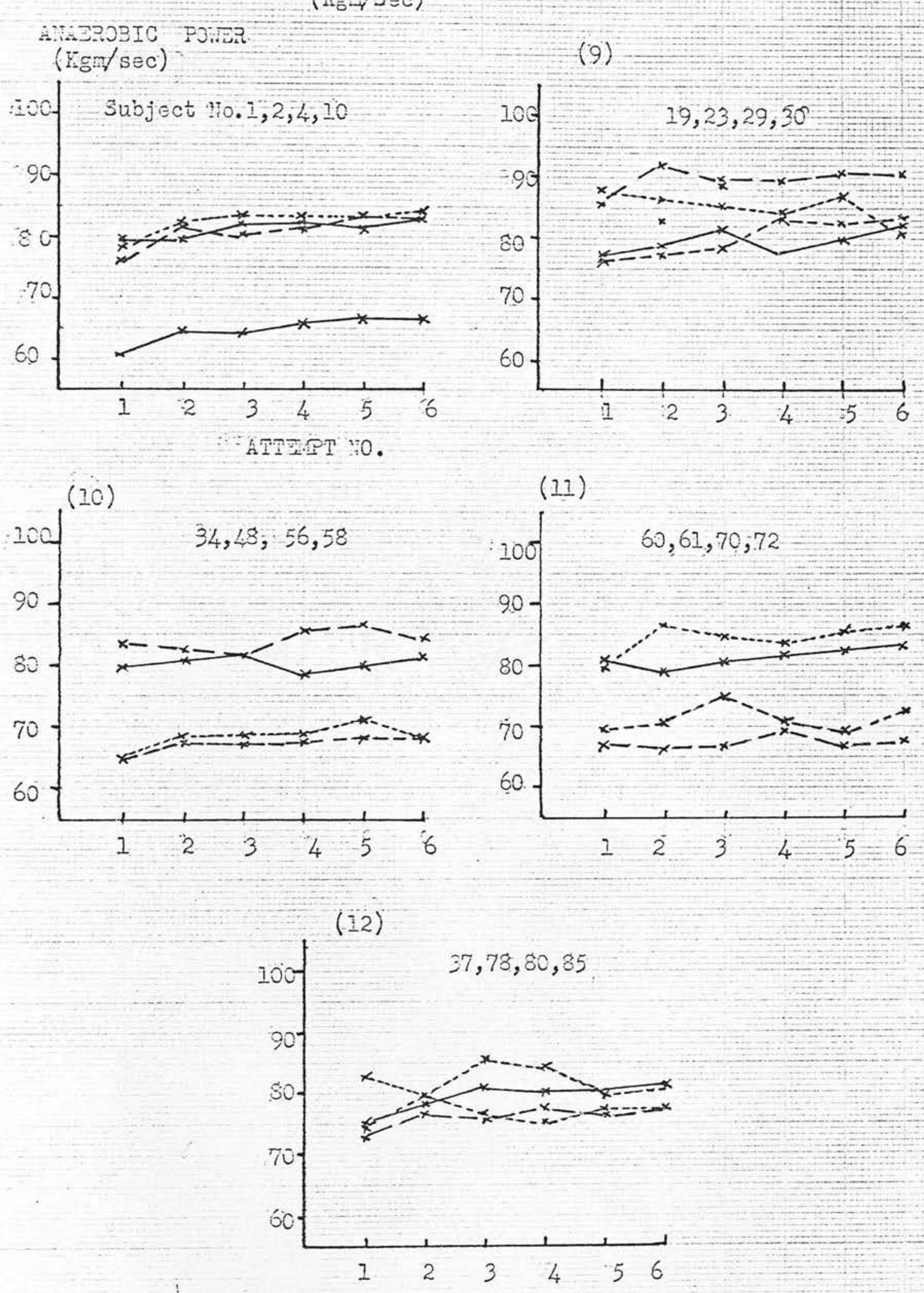


GRAPHS 8 to 28. The pattern of anaerobic power measured at each attempt by each subject in the main group.

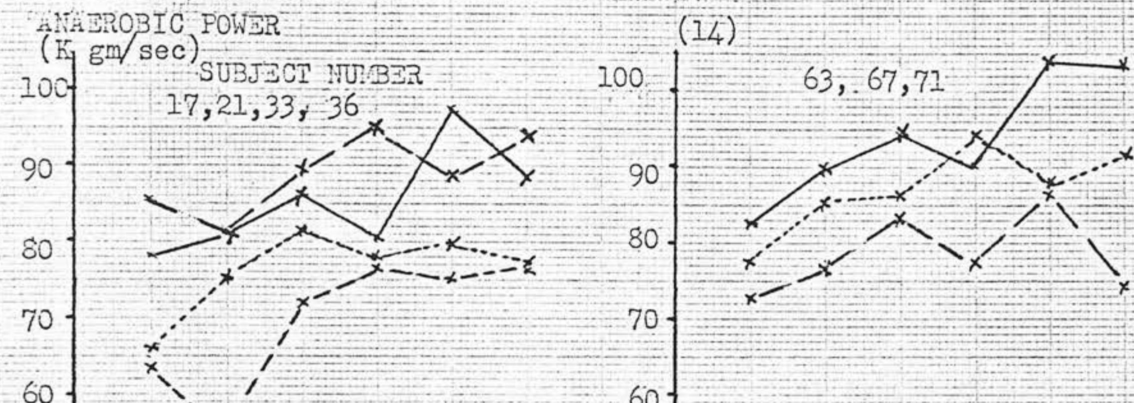
8 to 12	consistent pattern
13 to 15	inconsistent pattern
16 to 23	peaking pattern
24 to 28	improving pattern

Axes:	x Axis	anaerobic power (Kgm/sec)
	y Axis	Attempt number.

GRAPHS 8 - 12 ANAEROBIC POWER : CONSISTENT PATTERN
(Kgm/Sec)

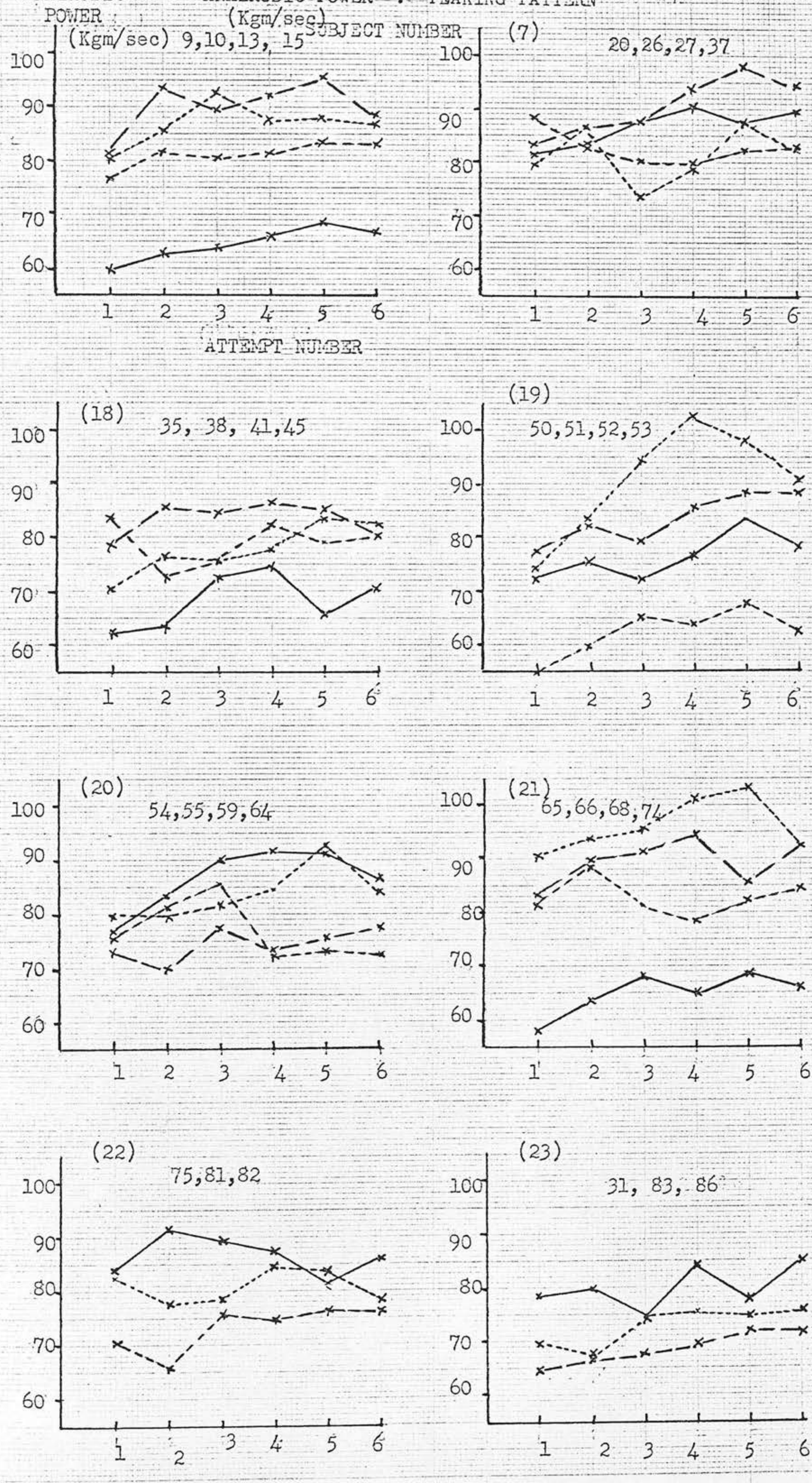


GRAPHS 13 - 15 ANAEROBIC POWER : INCONSISTENT PATTERN
(Kg m/sec).



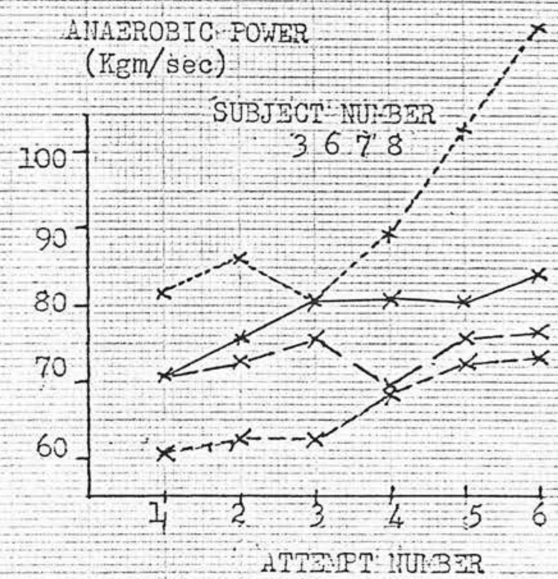
GRAPHS 16 — 23

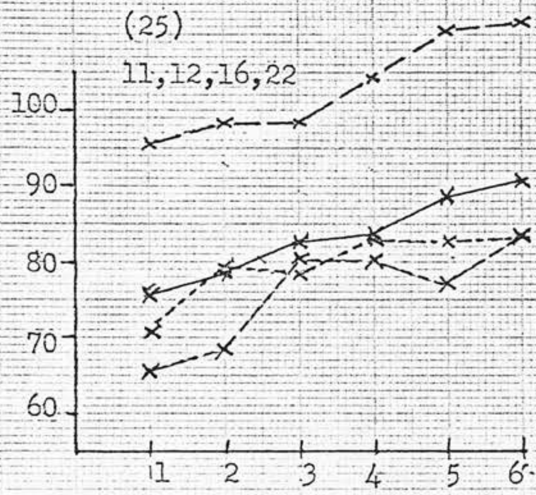
ANAEROBIC POWER : PEAKING PATTERN

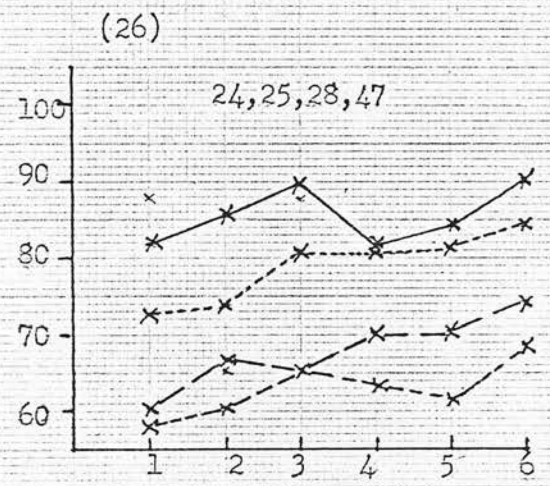


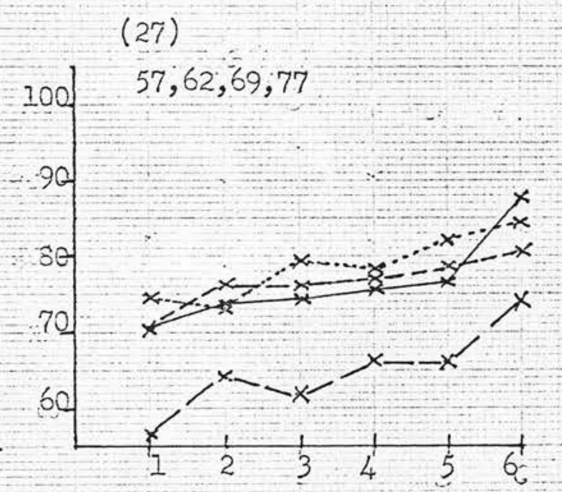
GRAPHS 24 -28 ANAEROBIC POWER : IMPROVING PATTERN

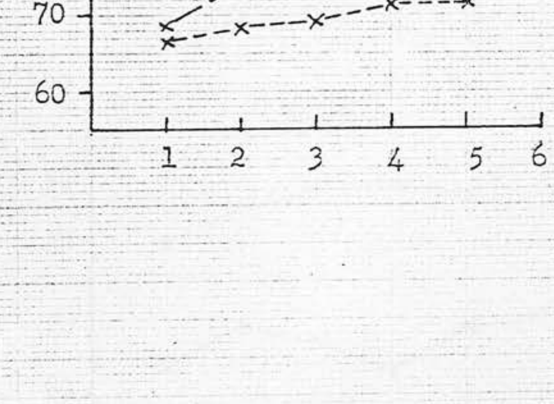
(Kgm/sec)







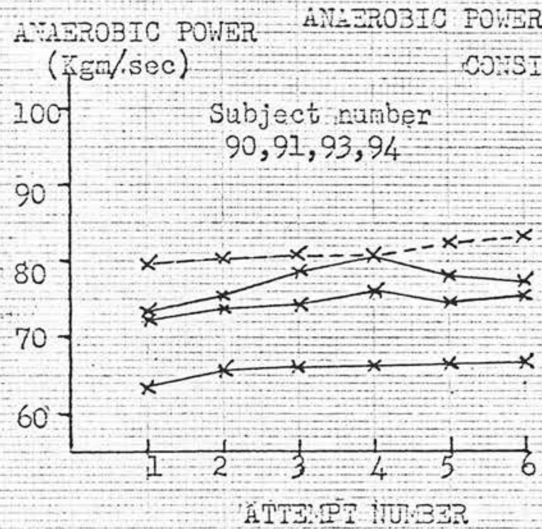




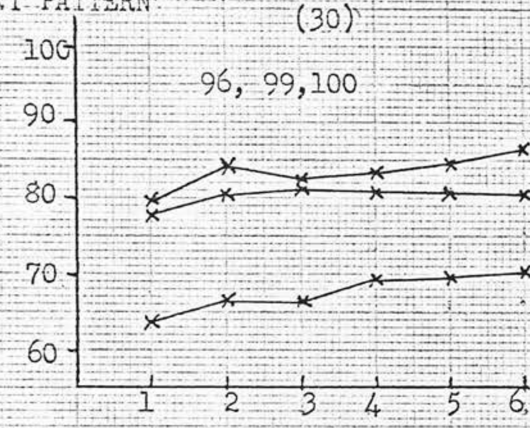
GRAPHS 29 - 33

ANAEROBIC POWER (Kgm/sec) Unmotiviated group

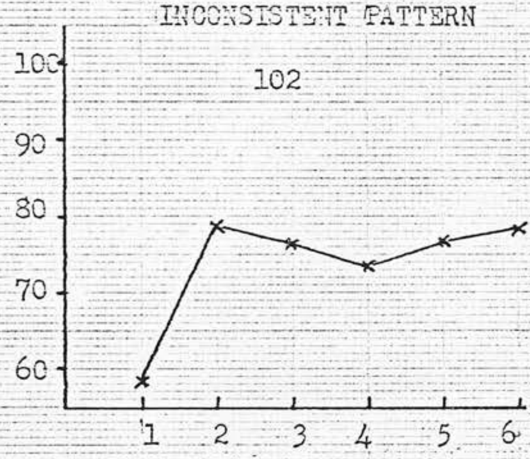
CONSISTENT PATTERN



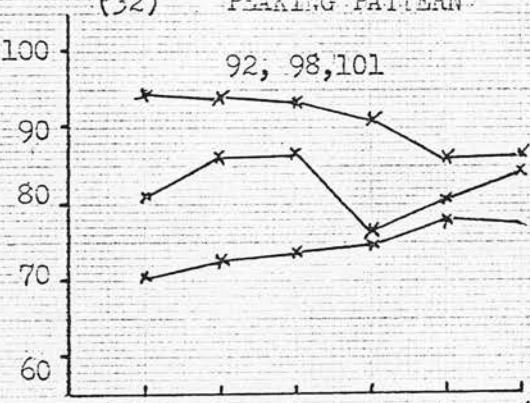
(30)



(31) INCONSISTENT PATTERN



(32) PEAKING PATTERN



(33) IMPROVING PATTERN

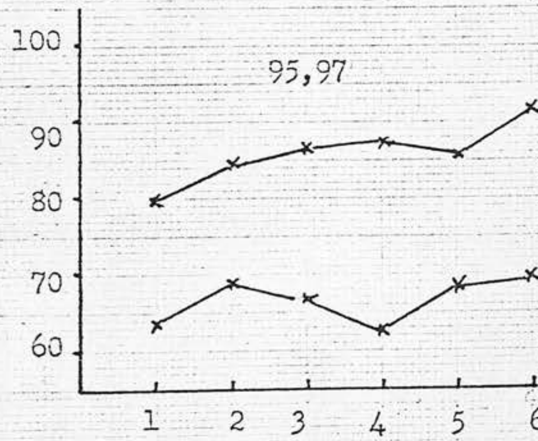


TABLE 1.

SUMMARY OF UNIVARIATE ANALYSIS OF DATA
USED IN THE REGRESSION EQUATIONS

VARIABLE	UNIT	N	MEAN	STANDARD DEVIATION	SKEW	KURT	MIN	MAX	SOURCE
Anaerobic Power	Kg.m sec	79	85.7	10.4	.500	.471	67.2	117.7	Computed Best Resul
Relative Anaerobic Power	Kg.m Kg.sec	79	1.46	.13	.175	.179	1.12	1.81	Computed Best Result
Time on Power Test	sec.	79	1.025	.094	.418	.561	.816	1.319	Raw Best Result
Basketball Throw	m.	77	15.2	2.9	.656	.747	9.7	24.7	Raw Best Result
Square of Basketball Throw		77	238.7	95.9	1.299	2.659	94.1	610.1	Computed Best Result
Vertical Jump Distance	m	86	.41	.06	.017	.430	.22	.55	Computed Best Result
Square Root of Vertical Jump Distance		86	.64	.05	-.288	1.026	.46	.74	Computed Best Result
50 Metre Run Time	sec.	74	8.3	.6	1.562	6.775	7.1	11.2	Raw
50 Metre Shuttle Run Time	sec.	77	13.8	1.5	-.399	-.415	10.6	17.0	Raw
Reciprocal of Shuttle Run Time		77	.073	.008	.810	-.159	0.59	.094	Computed
Age	yrs.	88	19.6	.6	.124	-.531	18.4	21.1	Raw
Arm Length	m	86	.684	.036	.652	.238	.618	.796	Raw
Leg Length	m	87	.759	.048	.519	2.780	.600	.928	Computed
Sitting Height	m	87	.871	.035	.346	.672	.770	.973	Raw
Height	m.	87	1.630	.066	.742	.762	1.494	1.834	Raw
Weight	Kg.	87	59.1	6.0	.632	.671	47.0	77.7	Raw

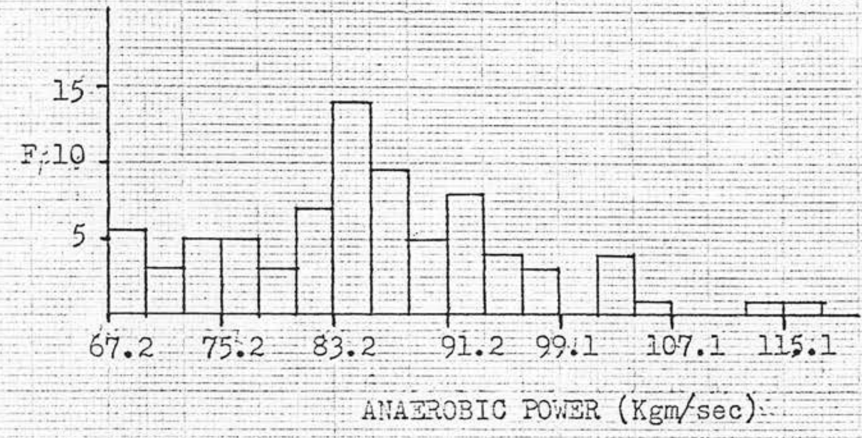
TABLE 2

SUMMARY OF RAW AND COMPUTED DATA RELATIVE TO UNMOTIVATED GROUP

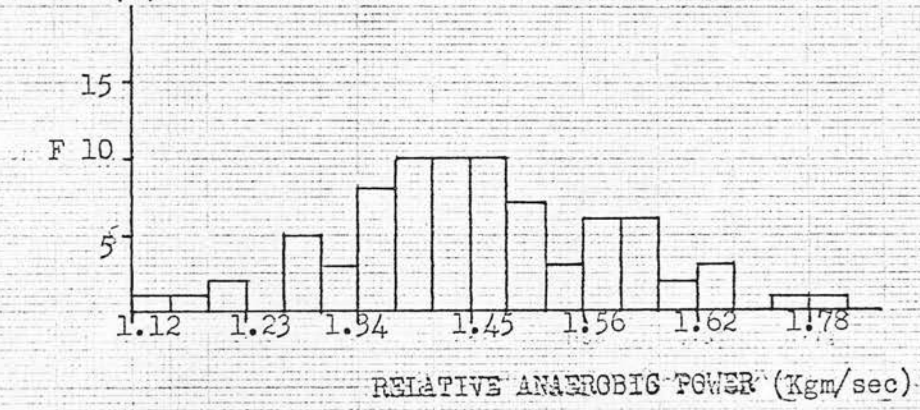
VARIABLE	UNIT	MEAN	STANDARD DEVIATION	MIN	MAX	DATA	N
Anaerobic Power	Kgm/sec	80.4	8.4	66.94	91.43	Computed Best Result	13
Relative Anaerobic Power	Kgm/sec	1.40	.11	1.19	1.58	Computed Best Result	13
Time on Stair Test	sec	1.090	.088	1.270	0.957	Raw Best Result	13
Age	yrs	20.1	.7	18.5	21.2	Raw	14
Leg Length	m	.77	.03	.72	.82	Computed	14
Sitting Height	m	.87	.02	.84	.92	Raw	14
Height	m	1.63	.05	1.56	1.74	Raw	14
Weight	Kg.	57.8	5.4	74.2	52.2	Raw	14

Histograms a - p. Distributions of raw and computed data used in the construction of regression equations.

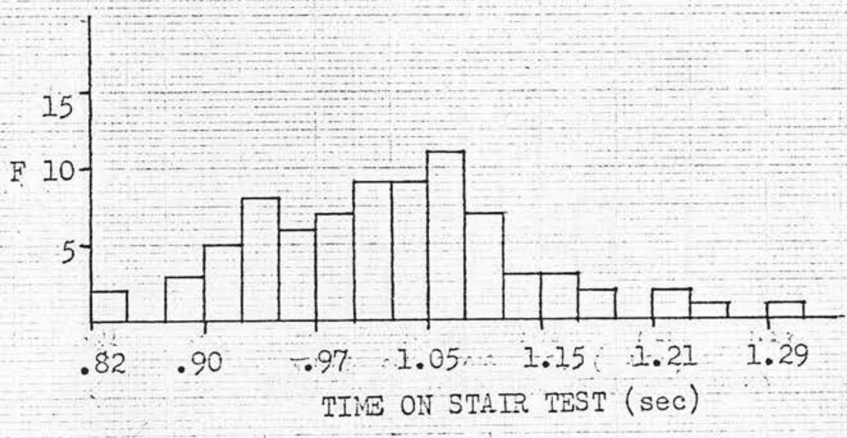
(a) ANAEROBIC POWER



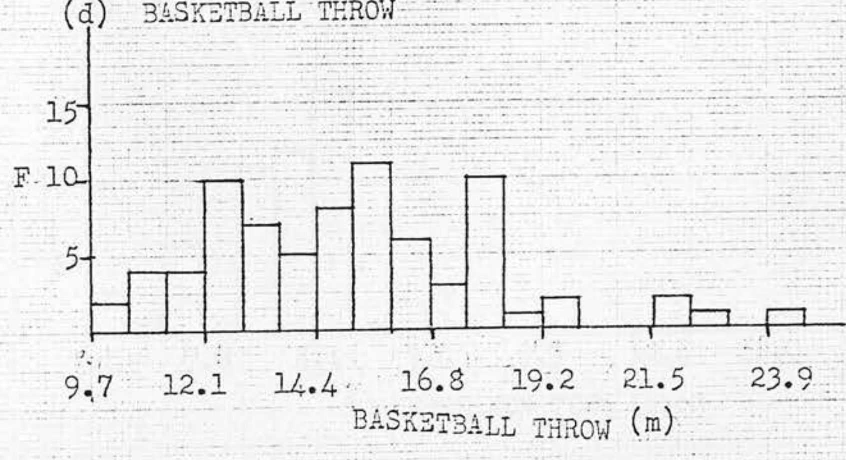
(b) RELATIVE ANAEROBIC POWER



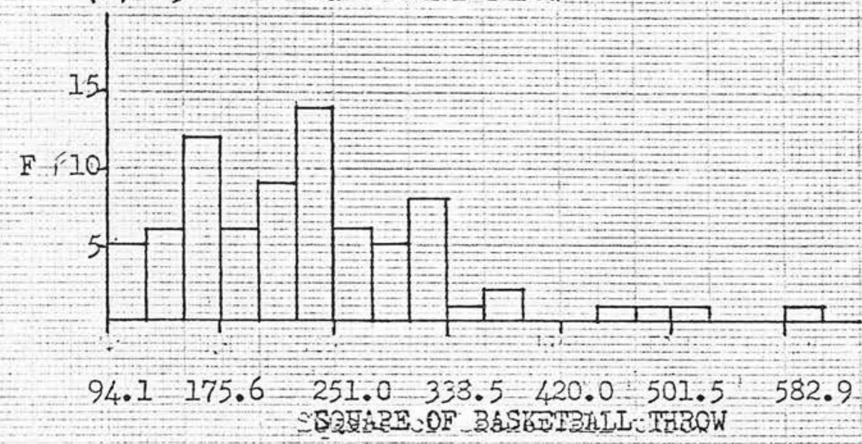
(c) TIME ON STAIR TEST



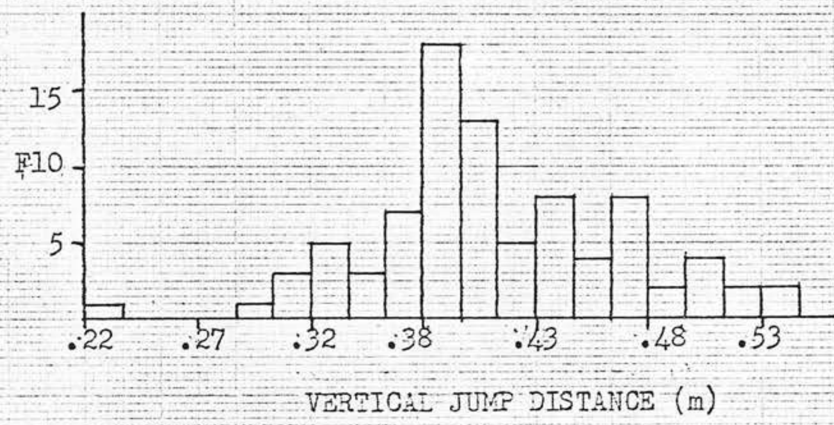
(d) BASKETBALL THROW



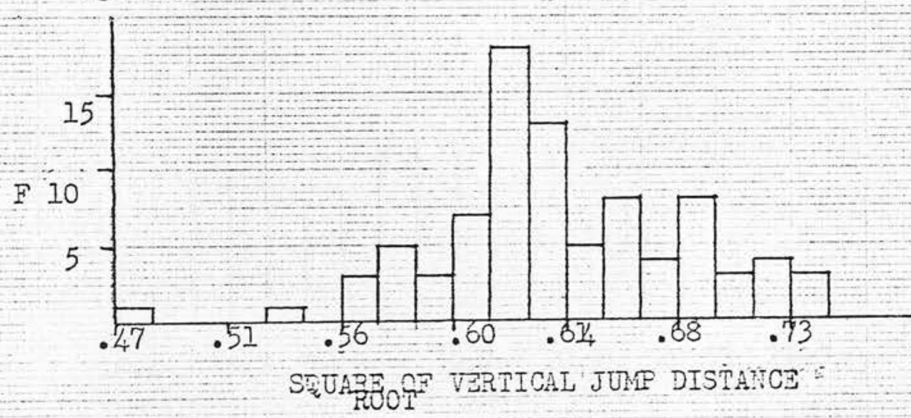
(e) SQUARE OF BASKETBALL THROW



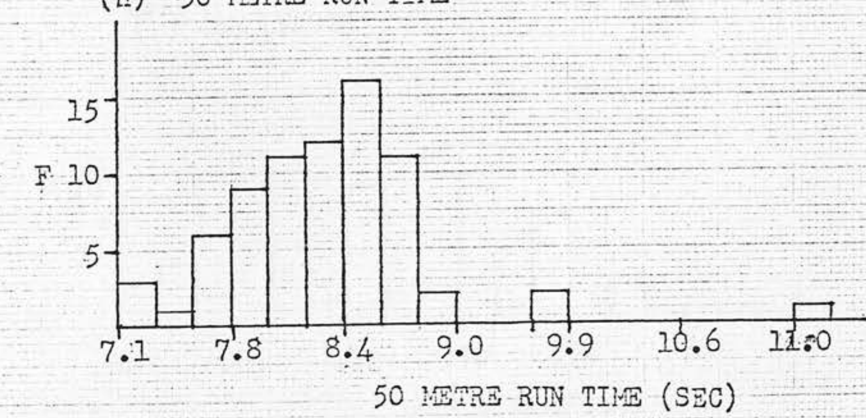
(f) VERTICAL JUMP DISTANCE

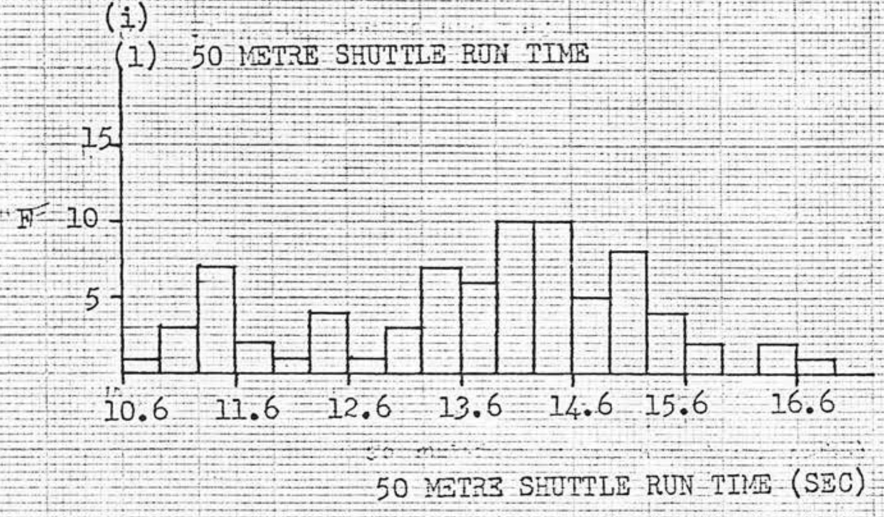


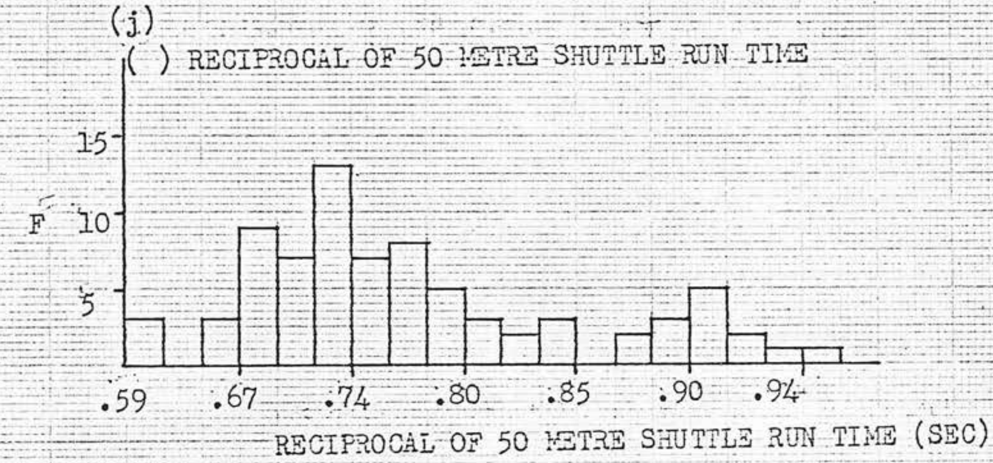
(g) SQUARE ROOT OF VERTICAL JUMP DISTANCE

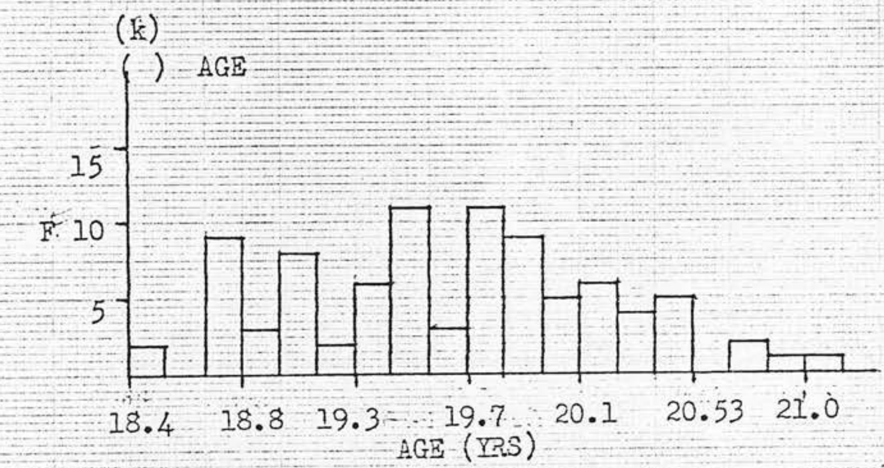


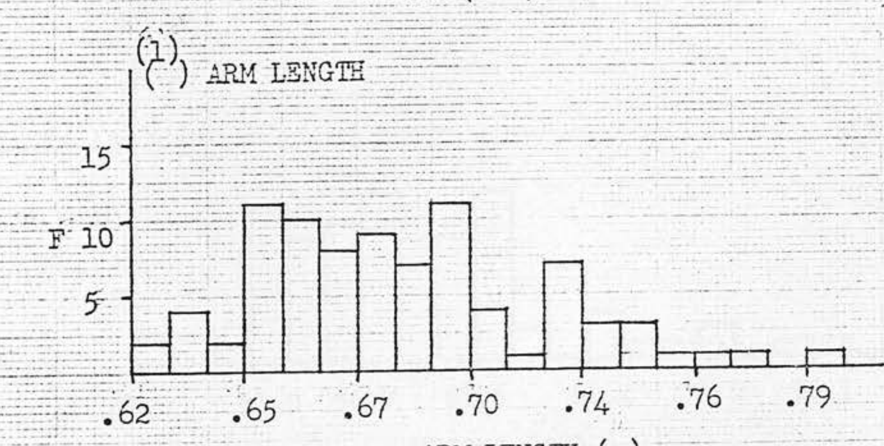
(h) 50 METRE RUN TIME

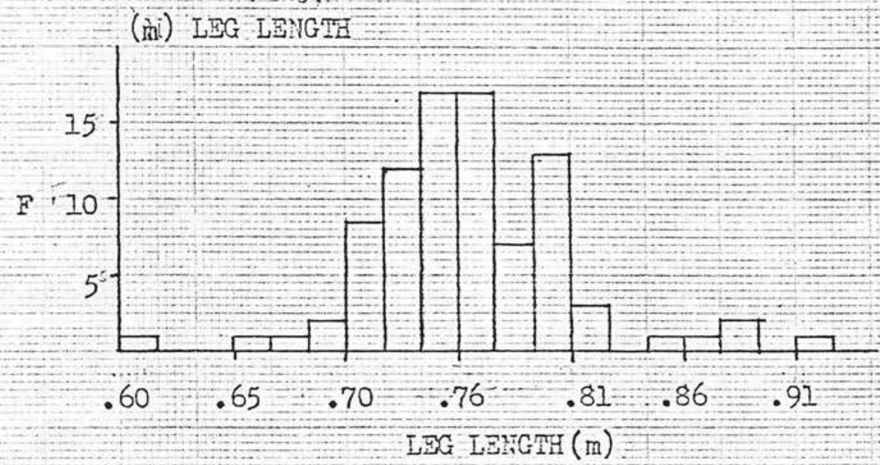


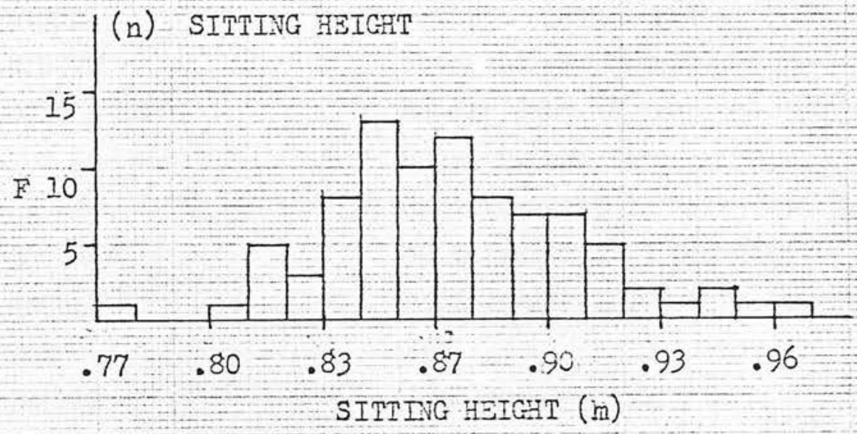

(i)
(1) 50 METRE SHUTTLE RUN TIME
15
F 10
5
10.6
11.6
12.6
13.6
14.6
15.6
16.6
50 METRE SHUTTLE RUN TIME (SEC)

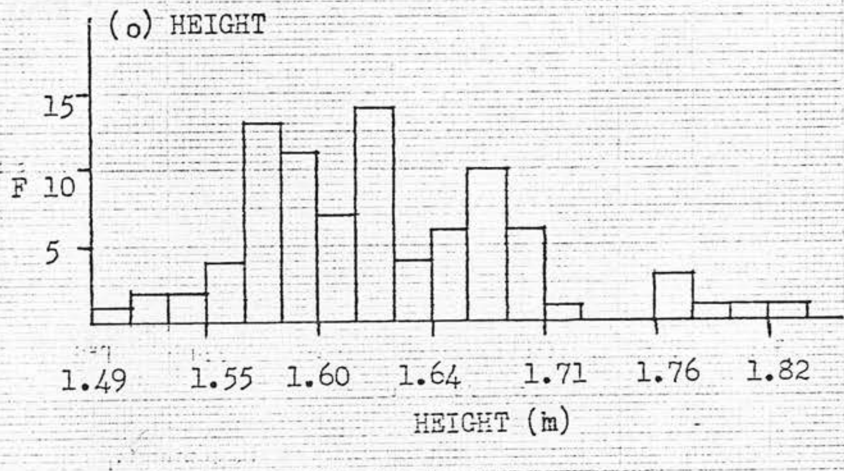

(j)
( ) RECIPROCAL OF 50 METRE SHUTTLE RUN TIME
15
F 10
5
.59
.67
.74
.80
.85
.90
.94
RECIPROCAL OF 50 METRE SHUTTLE RUN TIME (SEC)

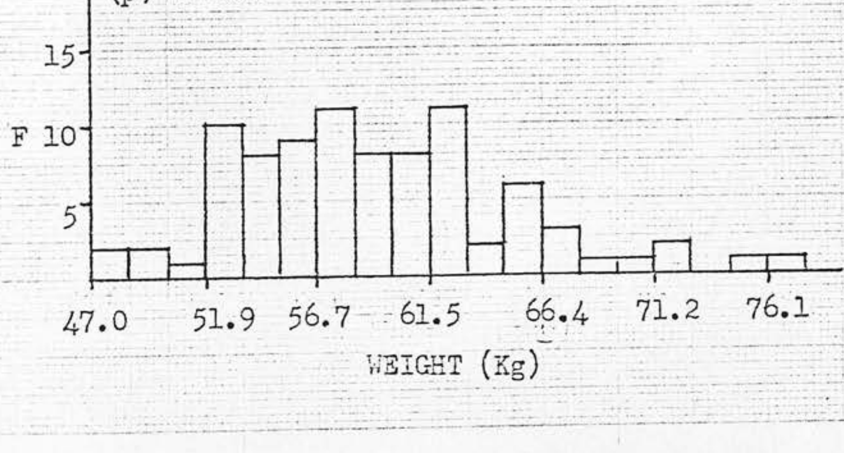

(k)
( ) AGE
15
F 10
5
18.4
18.8
19.3
19.7
20.1
20.53
21.0
AGE (YRS)


(l)
( ) ARM LENGTH
15
F 10
5
.62
.65
.67
.70
.74
.76
.79
ARM LENGTH (m)


(m) LEG LENGTH
15
F 10
5
.60
.65
.70
.76
.81
.86
.91
LEG LENGTH (m)


(n) SITTING HEIGHT
15
F 10
5
.77
.80
.83
.87
.90
.93
.96
SITTING HEIGHT (m)


(o) HEIGHT
15
F 10
5
1.49
1.55
1.60
1.64
1.71
1.76
1.82
HEIGHT (m)


(p) WEIGHT
15
F 10
5
47.0
51.9
56.7
61.5
66.4
71.2
76.1
WEIGHT (Kg)

Key of variables used in correlation matrix and regression analysis.

APOWER	Anaerobic power
RELAPOWER	Relative anaerobic power
T	Time on stair test
BBT	Basketball throw distance
BBT2	Square of basketball throw distance
BBT2 ROOT	Square root of basketball throw distance
DISTM	Vertical jump distance
DIST2M	Square of vertical jump distance
DIST 2 ROM	Square root of vertical jump distance
RUN 50	50 metre run time
INVR50	Reciprocal of 50 metre run time
SHUTRUN	50 metre shuttle run time
INVSHUTR	Reciprocal of 50 metre shuttle run time
AGE	Age
MARMM	Arm length
LEGL	Leg length
MSHT	Sitting height
XMHT	Height
WT	Weight

TABLE 3

Matrix of Pearson product-moment correlation coefficients (upper values) and associated significance levels (lower values) of dependant and independant variables.(N = 73)

TABLE 3.

	APOWER	RELAPOWER	TSEC	BBT	BBT 2
RELAPOWE	.660 <.001				
TSEC	-.648 <.001	-.991 <.001			
BBT	.351 <.001	.264 .012	-.268 .011		
BBT2	.363 .001	.273 .010	-.276 .009	.991 <.001	
BBT2ROOT	.343 .001	.259 .013	-.263 .012	.998 <.001	.980 <.001
DISTMM	.414 <.001	.456 <.001	-.446 <.001	.131 .136	.140 .118
DIST2M	.401 <.001	.442 <.001	-.425 <.001	.121 .155	.130 .136
DIST2ROM	.421 <.001	.463 <.001	-.456 <.001	.135 .127	.145 .110
RUN 50	-.410 <.001	-.527 <.001	.574 <.001	-.119 .159	-.126 .144
INVR50	.406 <.001	.507 <.001	-.543 <.001	.104 .192	.111 .175
SHUTRUN	-.248 .017	-.379 <.001	.381 <.001	-.096 .209	-.100 .199
INVSHUTR	.246 .018	.364 .001	-.363 .001	.085 .238	.089 .227
AGE	.316 .003	.263 .012	-.240 .020	.245 .018	.237 .022
MARMM	.469 <.001	.154 .096	-.125 .146	.123 .149	.122 .152
LEGL	.488 <.001	.169 .076	-.153 .099	-.053 .327	-.040 .367
MSHT	.364 .001	.041 .364	-.024 .422	.070 .278	.047 .346
XMHT	.546 <.001	.142 .115	-.121 .155	.001 .495	-.002 .492
WT	.650 <.001	-.140 .119	.148 .106	.190 .054	.196 .049

TABLE 3 continued (i)

	BBT 2 ROOT	DIST M	DIST2M	DIST2ROM	RUN 50
DISTM	.125 .146				
DIST2M	.115 .165	.997 <.001			
DIST2ROM	.130 .137	.999 <.001	.992 <.001		
RUN50	-.113 .171	-.394 <.001	-.373 ;001	-.405 <.001	
INVR 50	.098 .205	.375 .001	.360 .001	.383 <.001	-.988 <.001
SHUTRUN	-.094 .214	-.320 .003	-.307 .004	-.326 .002	.268 .011
INVSHUTR	.083 .243	.296 .005	.284 .007	.302 .005	-.238 .021
AGE	.247 .018	.182 .062	.192 .052	.176 .068	-.029 .404
MARMM	.125 .146	.364 .001	.371 .001	.360 .001	-.122 .153
LEGL	-.058 .312	.275 .009	.286 .007	.270 .011	-.225 .028
MSHT	.080 .250	.308 .004	.313 .004	.305 .004	-.140 .119
XMHT	.004 .488	.365 .001	.375 .001	.359 .001	-.236 .022
WT	.185 .058	.080 .249	.078 .257	.082 .244.	-.002 .494

	INVR 50	SHUTRUN	INVSHUTR	AGE
SHUTRUN	-.258 .014			
INVSHUTR	.231 .025	-.993 .001		
AGE	.057 .316	.123 .151	-.123 .150	
MARMM	.121 .154	-.260 .013	.263 .012	.174 .071

TABLE 3 Continued (ii)

	INVR50	SHUTRUN	INVSHUTR	AGE	MARMM
LEGL	.233	-.187	.192	-.025	.600
	.024	.057	.052	.417	<.001
MSHT	.162	-.144	.132	.250	.656
	.085	.113	.133	.016	<.001
XMHT	.254	-.211	.208	.122	.788
	.015	.036	.039	.153	<.001
WT	.016	.050	-.038	.152	.467
	.446	.336	.375	.099	<.001

	LEGL	MSHT	XMHT
MSHT	.249		
	.017		
XMHT	.842	.732	
	<.001	<.001	
WT	.485	.432	.582
	<.001	<.001	<.001

Key of statistics included in the summaries of data relating to the regression equations.

MULTR	Multiple correlation coefficient
RSQ	Multiple correlation coefficient square
ADJRSQ	Adjusted multiple correlation coefficient squared
F (R)	F test for multiple correlation coefficient
SIG F (R)	Significance of F test
RSQCH	Change in multiple correlation coefficient between last step and current step.
SIGCH	Significance of change in multiple correlation coefficient
B	Unstandardized regression coefficient
SEB	Standard error of B
95% CONF INT	95% confidence interval of B
BETA	Standardized regression coefficient
F	F test for regression coefficient
SIG F	Significance of F test.

EQUATION NUMBER	VARIABLES AND APPROPRIATE BETAS					ADJUSTED R SQUARE
1	WT .611	RUN 50 -.296	DIST2ROM .161	AGE ·20.8	INVSHUTR .176	.673
2	WT .596	RUN 50 -.295	DIST2ROM .226	BBT2 .177		.649
3	WT 1.629	RUN 50 -.311	DIST2ROM .243			.639
4	WT .599	RUN 50 -.300	DISTM .225	BBT .172		.647
5	WT .630	RUN 50 -.314	DISTM .240			.623
6 *	DISTM .278	RUN 50 -.278	SHUTRUN -.084			.218

SQUARED
TABLE 4 BETAS AND ADJUSTED/MUTLIPLE CORRELATION
COEFFICIENTS OF EQUATIONS USED TO PREDICT
ANAEROBIC POWER

*entry criteria relaxed p in = 0.5

EQUATION NUMBER	VARIABLES AND APPROPRIATE BETAS					ADJUSTED R SQUARE
7	RUN 50 -.380	DIST2ROM .204	AGE .274	INVSHUTR .238	WT -.190	.442
8	RUN 50 -.407	DIST2ROM .298				.334
9	RUN 50 -.411	DISTM .294				.333
10 *	RUN 50 -.378	DISTM .244	SHUTRUN -.199			.359
11 *	RUN 50 -.383	DISTM .246	INVSHUTR .199			.360

TABLE 5 BETAS AND ADJUSTED SQUARED MULTIPLE CORRELATION COEFFICIENTS OF EQUATIONS USED TO PREDICT RELATIVE ANAEROBIC POWER

* entry criteria relaxed p in = 0.5

TABLE 6. DATA RELATING TO THE REGRESSION EQUATION FOR ANAEROBIC POWER DERIVED FROM ALL VARIABLES EXCLUDING AGE, POWERS, ROOTS AND RECIPROCALS OF VARIABLES AND BASKETBALL THROW

(EQUATION 5)

(a) PROGRESS OF STEPWISE REGRESSION

Step	Variable	MULTR	RSQ.	ADJRSQ	F(R)	SIG F (R)	RSQCH	SIGCH
1	WT	.650	.423	.415	52.0	<.001	.423	<.001
2	RUN 50	.768	.590	.579	50.4	<.001	.168	<.001
3	DISTM	.799	.638	.623	40.6	<.001	.048	.003

(b) STATISTICS ASSOCIATED WITH EQUATION

Variable	B	SEB	95% CONF INT		BETA	F	SIGF
WT	1.202	.139	.926	1.479	.630	75.2	<.001
RUN 50	-5.198	1.301	-7.794	-2.603	.315	15.0	<.001
DISTM	42.526	14.042	14.514	70.539	.240	9.2	.003
CONSTANT	40.477	14,750	11.052	69.903		7.5	.008

(c) REGRESSION EQUATION

Anaerobic Power = 1.202 (weight)
- 5.198 (50 m. run time)
+ 42.526 (vertical Jump Distance)
+ 40.477

(d) STANDARD ERROR 6.16

TABLE 7.

DATA RELATING TO REGRESSION EQUATION FOR RELATIVE ANAEROBIC POWER USING 50 M. RUN TIME, VERTICAL JUMP DISTANCE AND SHUTTLE RUN TIME AS PREDICTORS (EQUATION 10)

Step	VARIABLE	MULTR	RSQ	ADJRSQ	F	SIG F	RSQCH	SIGCH
1	Run 50	.527	.278	.268	27.3	< .001	.278	< .001
2	Dist M	.593	.351	.333	19.0	< .001	.073	.005
3	SHUTRUN	.621	.386	.359	14.5	< .001	.035	.052

VARIABLE	B	SE B	95% CONF	INT	BETA	F	SIG F
Run 50	-081	.022	-.126	-.036	-.378	13.2	.001
Distm	-.562	.244	.075	1.049	.244	5.3	.024
SHUTRUN	-.018	.009	-.037	.001	-.199	3.9	.052
CONSTANT	2.152	.248	1.658	2.646		75.5	< .001

REGRESSION EQUATION

Relative anaerobic power = .562 (verticial jump distance)
-.081 (50m. run time)
- .018 (50m shuttle Run Time)
+ 2.152

STANDARD ERROR 0.104

DISCUSSION

The intention of the data collection and analysis was primarily to establish regression equations for the dependant variables anaerobic and relative anaerobic power. The secondary aim was to investigate the effects of motivation on the power test.

The correlation matrix produced from the dependant and predictor variables (Table 3) produced several noteworthy points. The effects of data transformation of predictor variables was, in all cases, very restricted in terms of the variation in correlations which were produced with the dependant variables. For example the largest change in correlation coefficient was a change from - .527 between 50 m. run time and relative anaerobic power to .507 between the reciprocal of 50 metre run time and relative anaerobic power. The absence of any marked improvement in correlation coefficients as a result of the use of speed measures (i.e. reciprocals of run times) was unexpected in view of the manner of calculation of power, which also involves the use of reciprocal of time. It may be that in this relatively homogenous group of subjects (i.e. same sex, age and physical background) the spread of data was insufficient to result in any major change of correlations as a result of data transformations.

It was also unexpected that age should form significant ($P < .05$) positive correlations with both the power measurements and a number of the predictor variables. There is no logical reason why age should be related to performance on the dependant variables over the restricted age range from which the subjects were taken, although Margaria (1966) presents evidence that over a larger age range (10-20 years), relative anaerobic power increases whilst between 20 and 70 years there is in general a decrease in power.

Of the variables available in the regression analysis, that is all variables in the correlation matrix excluding the dependant variables and the time measurement, weight has the highest single correlation with either of the dependant variables (0.650 with anaerobic power).

The reason for this is clearly that weight forms a component in the calculation of anaerobic power. In contrast, there is an insignificant ($P > .05$) correlation between weight and relative anaerobic power. This suggests that there is a fundamental difference between anaerobic and relative anaerobic power in that the anaerobic power measurement is dominated by weight. The highest single correlation between a predictor variable and relative anaerobic power is that of 50 metre run time which amounts to - 0.527 ($P < .001$).

Of the performance predictor variables used the lowest correlations with the dependant variables are between basketball throw and relative anaerobic power and shuttle run and anaerobic power. Shuttle run is recognised to contain an element of agility which may explain its poor correlation. Basketball throw is essentially a measure of arm power and the dependant variables are both measuring mainly leg power. The relatively low correlation between basketball throw and relative anaerobic power is partly a result of the relative independance of leg and arm power. In addition the mechanical pattern of throwing is critical for performance on basketball throw. This pattern does not appear to be dependant on arm length (the correlation between arm length and basketball throw is .123, $p > .05$) but, from observation by the tester, on the testee's skill in throwing. In general the pattern of throwing was not greatly modified over the six attempts allowed thus the testees who could be identified as having a poor grasp of this skill at the first throw continued to throw in the same manner for the rest of the attempts in spite of demonstration of the optional throwing pattern. It must be concluded that basketball throw is a relatively poor measure of muscle power.

This quality of basketball throw in relationship to the power measurements is further recognised in the construction of the regression equations. Basketball throw is the only performance predictor variable which is not selected for the equations which were used to predict relative anaerobic power and in the equations where it was included in the prediction of anaerobic power basketball throw was always the last variable to be included and possessed the lowest standardized regression coefficient.

In spite of the significant correlation coefficients which were calculated between the anthropometric measurements and anaerobic power only weight was included in the regression equations. The reason for this is that weight and the other anthropometric measures have high intercorrelations so that when weight has been included in theequation the anthropometric measures do not make a significant contribution to the explanation of the remaining variability in the dependant variable. Weight was always the first variable to enter when it was available for inclusion in equations for the prediction of anaerobic power and in terms of the standardized regression coefficients was always the single greatest contributor to the equation. This is related to the manner in which anaerobic power is calculated which results in considerable dependance on body weight. In contrast the regression equations for relative anaerobic power only include weight in equations 1 where it is the smallest contributor (beta = - .190). This further supports the use of relative power as a measure of the efficiency of the metabolic processes in the muscle fibres - a process which is independant of body weight - rather than absolute anaerobic power which depends substantially on body weight.

Data transformations, including both the calculation of 50 metre run and shuttle run in the form of speed and the derivation of squares and square roots of performance variables have little effect on the regression equations. In the case of anaerobic power equations 3 and 5 are comparable in that similar predictor variables are used except that in equation 3 the square root of vertical jump distance is used and in equation 5 the untransformed variable itself is included. The adjusted squared multiple correlation coefficient which gives a measure of the variability of the dependant variable which is explained by the derived equation is 0.639 for equation 3 and 0.623 for equation 5. From this it can be calculated that the use of square root of vertical jump distance has contributed a further explanation of 1.6% of the variability in anaerobic power over that contributed by the use of the raw value of vertical jump distance.

A similar effect is noticable in equations 2 and 4 where the inclusion of square root of vertical jump distance and the square of basketball throw contributes a further 0.2% of explained variance over the inclusion of the raw data.

In/

In equations predicting relative anaerobic power the inclusion of the reciprocal of shuttle run produces an adjusted multiple correlation coefficient of .360 in equation 11 in comparison to .359 where the raw data value for shuttle run time is included (equation 10). From this it seems that only minor improvements can be made in the prediction of power by transforming the data. These improvements are not sufficient to warrant the extra work necessary to produce them.

Of the regression equations derived, numbers 1 and 7 have the highest adjusted squared multiple correlation coefficients and hence are the most efficient at explaining variations in the appropriate dependant variables. However in both equations age was selected as a predictor variable and in view of its lack of logical relationship to the dependant variables it was excluded in order to derive equations 2 - 6 and 8 - 11. Similarly equations 3, 5 and 6 were derived by excluding basketball throw or the variable derived from basketball throw. In equation 5 only raw predictor variables were allowed to enter the equation. The restrictions which were placed on entry of variables into the equations for the prediction of anaerobic power caused reductions in the adjusted squared multiple correlation coefficient from .673 in the case of equation 1 to .623 in the case of equation 5. This 5% reduction in the amount of explained variability in anaerobic power is acceptable in view of the logical necessity of preventing age and basketball throw from entering the equations. Of the equations produced for the prediction of anaerobic power, equation 5 presents the best compromise between the desirability of excluding age and basketball throw whilst maintaining the largest possible value for the explained variation in the dependant variable.

A similar pattern emerges from the analysis of the regression equations for relative anaerobic power. When age is excluded neither the reciprocal of shuttle run time nor body weight enter the regression equation. This is a result of changes in the probability of the F values which determine entry into the equations. When age is allowed to enter the equation, the probability of the F value for reciprocal of shuttle run to enter at step 4 is .014 and for weight to enter at step 5 is .037. However when age is prevented from entering the equation the probabilities of the F-to-enter at step 3 for reciprocal of shuttle run time and weight are 0.052 and 0.085

respectively. Since these exceed the entry criterion of $p < .05$ these variables do not enter the equation when age is excluded. However if the entry criterion is relaxed sufficiently to allow the variable shuttle run or its reciprocal to enter the equation after 50 metre run time and vertical jump distance, the explained variability rises from 33.4% to 35.9% in the case of shuttle run time and 36.0% in the case of reciprocal of shuttle run time. These changes are not significant ($p = 0.052$) but in view of the relatively low probability value and taking into account the restricted sample used it would be worthwhile to include 50 metre shuttle run in the collection of further data with a view to widening the applicability of the regression equations. As discussed earlier the advantage gained by including reciprocal of shuttle run time rather than the raw value is too small to justify it, so that the most useful regression equation for the prediction of relative anaerobic power derived from the data collected is equation 10. Equation 6 shows the prediction of anearobic power from the variables which give the most useful prediction of relative anearobic power. Since the adjusted squared multiple correlation coefficient for this equation is .218 it can be seen to be inadequate as a means of prediction in comparison with equation 5.

In considering the changes in the adjusted squared multiple correlation coefficient during the course of the building of equations 5 and 10 it can be seen from tables 6 and 7 that there is an improvement from .413 to .623 for anearobic power and from .268 to .359 for relative anaerobic power. Of the total explained variance for equation 5 (62.3%), weight contributes 41.3%, 50 metre run time a further 16.8% and vertical jump distance a further 4.8%. For equation 10 the total explained variance (35.9%) comprises of 27.8% explained by 50 metre run time, a further 7.3% explained by vertical jump distance and a further 3.5% explained by 50 metre shuttle run time. From this it may be concluded that significant improvements are made in the prediction of anaerobic and relative anaerobic power by the inclusion of more than one variable in the prediction process.

In terms of the standard errors calculated for the regression equations, the value for equation 5 is 6.156 and for equation 10 is 0.104. A prediction of anaerobic power which coincided with the mean of the data collected (85.7 Kgm/sec) would have 95% confidence limits of 73.5 Kgm/sec and 97.9 Kgm/sec. For relative anaerobic power a prediction corresponding with the mean would have 95% confidence limits of 1.26 Kgm/Kg sec and 1.66 Kgm /Kgsec. In spite of the width of these confidence limits, predicted anaerobic and relative anaerobic power remain useful in that the would not be used on their own to predict, for example, the possibility of success of an individual in a specific activity but would be used in conjunction with other predictors. In addition repeated measures of predicted power over a period of months would also tend to reduce the width of the confidence limits.

The relatively low explained variability of relative anaerobic power (35.9%) in comparison to anaerobic power (62.3%) could be interpreted as suggesting that the relative power measurement is a measure of a quality- presumed to be power - which is not measured very accurately by performance variables and that in anaerobic power this quality is swamped by the presence of weight in the equation.

The results which relate to the subsidiary aim of the experiment (to determine the influence of motivation) suggest that in the performance variables, motiviation is not an important limiting factor.

The patterns for all the repeated variables (power measurement, vertical jump and basketball throw) in general show a trend upwards with - in the case of the power measurement the formation of a plateau.

In most individual patterns the peak power measure falls at some point during the first 5 attempts. Of those whose peak falls during the sixth attempt, i.e. the improving pattern, some subjects appear to have almost reached a plateau whereas others appear still to be achieving definite improvements. For these subjects it would be necessary to make a seventh or eighth attempt in order to ensure that the maximum value had been reached.

The graphs showing the pattern of basketball throw (graphs 34 - 53) present patterns which can be interpreted as showing the importance of technique on throw distance. Graph 52 shows examples of a pattern which may reflect a loss of technique on the fourth throw whereas Graph 36 shows a subject who mastered the optimum technique early on in the sequence and was able to maintain the pattern thereafter. It is unlikely that a group of subjects who were poorly motivated would produce results which fell into the general pattern shown by these graphs it being more likely that lack of motivation would result in consistent or reducing results. This conclusion is supported by the statistical analysis which was carried out on the data collected for power from the small unmotivated group. Although average performance on this test was lower in the unmotivated group than in matched subjects taken from the main group, the difference was not statistically significant. It would appear that in the larger group of subjects who have a relatively positive attitude towards physical activity in general, the effects of lack of motivation on the power test performance are negligible, although the results do suggest that more than five trials are necessary to produce a maximum result. It is uncertain whether this pattern is applicable to subjects who are less interested in physical activity and might be expected to be less motivated than the subjects used in this experiment.

The results collected on the power test conform fairly closely with published results collected by other authors. In terms of relative anaerobic power Margaria (1966) recorded results varying from 1.05 to 1.90 Kgm/Kg sec for a group of 20 year old female athletes and non athletes. Withers et al (1979) using a similar technique and subjects produced an average relative anaerobic power of 1.45 Kgm/Kg sec for 23 subjects. The average in this study was 1.46 Kgm/Kgsec. Similar agreement exists with data for anaerobic power. In the study just referred to the average value for anaerobic power measured using the same technique was 85.0 Kgm/sec. In this study the average anaerobic power was calculated as 85.7 Kgm/sec.

The significant correlation between anaerobic power and 50 metre run time found in this study ($r = -.410$) corresponds to a significant correlation ($r = -.974$) found between the same two variables in a male sample by Kalamen (1968) although in that study a sample of only seven were used. The same author found no significant correlation between vertical jump distance and anaerobic power ($r = .581$) although here again the sample consisted of seven subjects.

Costill et al (1968) reported significant correlations ($p < .05$) between anaerobic power and vertical jump distance, and weight and between relative anaerobic power and vertical jump distance, 40 yard run and weight. This contrasts with this study in that from the data collected here, weight and relative anaerobic power are not significantly correlated. Also in spite of the high correlation between weight and anaerobic power ($r = .848$) reported by Costill and the generally observed correlation between height and weight, these authors do not record a significant correlation between height and anaerobic power.

The study by Costill involved a sample of 74 males, 66 of whom were members of a football team. The specificity of this group may have resulted in a different pattern of correlations to that derived for the female physical education students used in this experiment. The data collected from the latter produced a correlation of .546 ($P < .001$) between height and anaerobic power.

SOURCES OF ERROR.

This study was carried out using a technique similar to that described by Margaria (1966) who had found that performing the stair test by climbing two stairs at a time (amounting to a total height of ·35m) produced optimal test results. Other studies by Kalamen (1968) and Withers (1979) suggest that the optimal power result may be produced by instructing subjects to climb three steps at a time giving a total height of approximately .52m at each jump. The use of a two-stair jump in this test may have resulted in the power measurements made being less than optimal for the subjects used. A further restriction of this test is seen in that it is essentially a test of leg power. Whilst leg power is of importance in some of the activities which involve the breakdown of high energy, phosphates in the muscles as an energy source e.g. jumping sprinting etc. other activities where the energy source is the same e.g. throwing depend largely on the ability of muscle groups other than those involved in leg movement.

In some cases, the anaerobic power measurement may not have been the best result that the individual was capable of. This is particularly so in the case of the results where an improving pattern was observed. Further repititions of the test would have shown whether the individual had produced a maximum result. A similar pattern of responses was also detected in the basketball throw and vertical jump test and here as well further repetitions may have given a better result in some individuals. It was not considered feasible to repeat measures of 50 metre shuttle run time or 50 metre run time and here also it is possible that improvement may have been made over the result measured on one attempt.

The digital timer used in the measurement of time on the stair test was accurate to ± 0.5%. This inaccuracy would be reflected in the calculated power values although since the potential inaccuracy of the timer was minimal the innaccuracy arising from this source would be minimal.

The method of switching the timer on and off is also a possible source of error. Withers et al (1979) found that time on a similar test was consistently less (resulting in an apparent increase in performance) when timed using photocells rather than switchmats. The average reduction in the calculated power output when switchmats were used amounted to 2.0%. These authors conclude that the reduction in power output is due to delay in the off-switching device and that the times recorded by photocells give a more accurate measure of test performance.

Timing of the performance predictor variables 50 metre run time and 50 metre shuttle run time was carried out by use of a stopwatch. The scope for error in these measurements lies partially in the accuracy of the stopwatch and partially in the ability of the tester to respond consistently at the start and finish of each run.

In general, since the subjects in this sample represented a relatively specialized group of individuals who have considerable interest, skill and experience in physical activity it is possible that the results of the data collection and analysis may not be applicable to subjects with substantially different backgrounds. This problem is reflected by other work in this field (e.g. Kalamen 1968 Costill 1968 Withers 1979) where data has been collected from subjects who specialize in physical education and therefore who are not representative of the normal adult population. In addition the subjects were chosen from a relatively small age range and subjects of other ages may require different equations in order to predict anaerobic and relative anaerobic power. Since the best predictors of anaerobic power are body weight, 50 metre run and vertical jump distance and of relative anaerobic power are 50 metre run, 50 metre shuttle run and vertical jump distance further work on the derivation of regression equations for the prediction of power could usefully be carried out by collecting data on these variables from a more widely divergent population than was used in this experiment.

CONCLUSION

The data was collected in order to determine the most accurate way of predicting anaerobic and relative anaerboic power from a variety of anthropometric and performance predictor variables. The regression equations which were derived from this data were:

Anaerobic Power = 1.202 (weight) Kg.
- 5.198 (50 metre run time (sec.
+ 42.526 (vertical jump height) m.
+ 40.477

Relative Anaerobic Power = .562 (vertical jump distance) m.
-.081 (50 metre run time) sec.
- 0.018 (50 metre shuttle run time) sec.
+ 2.152.

These equations explained 62.3% and 35.9% of the variability in the respective dependant variables. Since the predictor variables used only explain a small proportion of the variability of relative anaerobic power it may be more satisfactory to measure this variable rather than to attempt to predict it.

The use of more than one variable to predict power makes a significant improvement in the accuracy with which power can be predicted. In both cases the least useful of the performance predictor variables measured was basketball throw and anthropometric variables other than weight were not included in the regression equations.

The results suggest that lack of motivation was not an important factor in performance on the power test or on the performance predictor variables.

The equations derived are essentially of use for predicting power only for a similar sample to that which was used in the data collection. It would be most profitable to collect data for weight, 50m run time, 50 metre shuttle run time and vertical jump distance from a wider population in order to derive regression equations which would have wider applications.

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APPENDIX 1.

Graphs 34 - 40 Basketball throw at each attempt of subjects classified as having a 'peaking' pattern of throws.

Graphs 41-43 Basketball throw at each attempt of subjects classified as having an 'improving' pattern ofthrows.

Graphs 44-48 Basketball throw at each attempt of subjects classified as having a 'consistent' pattern of throws.

Graphs 49 - 53 Basketball throw at each attempt of subjects classified as having an'inconsistent' pattern of throws.

Graphs 54- 58 vertical jump distance at each attempt of subjects classified as having a 'consistent' pattern of jumps.

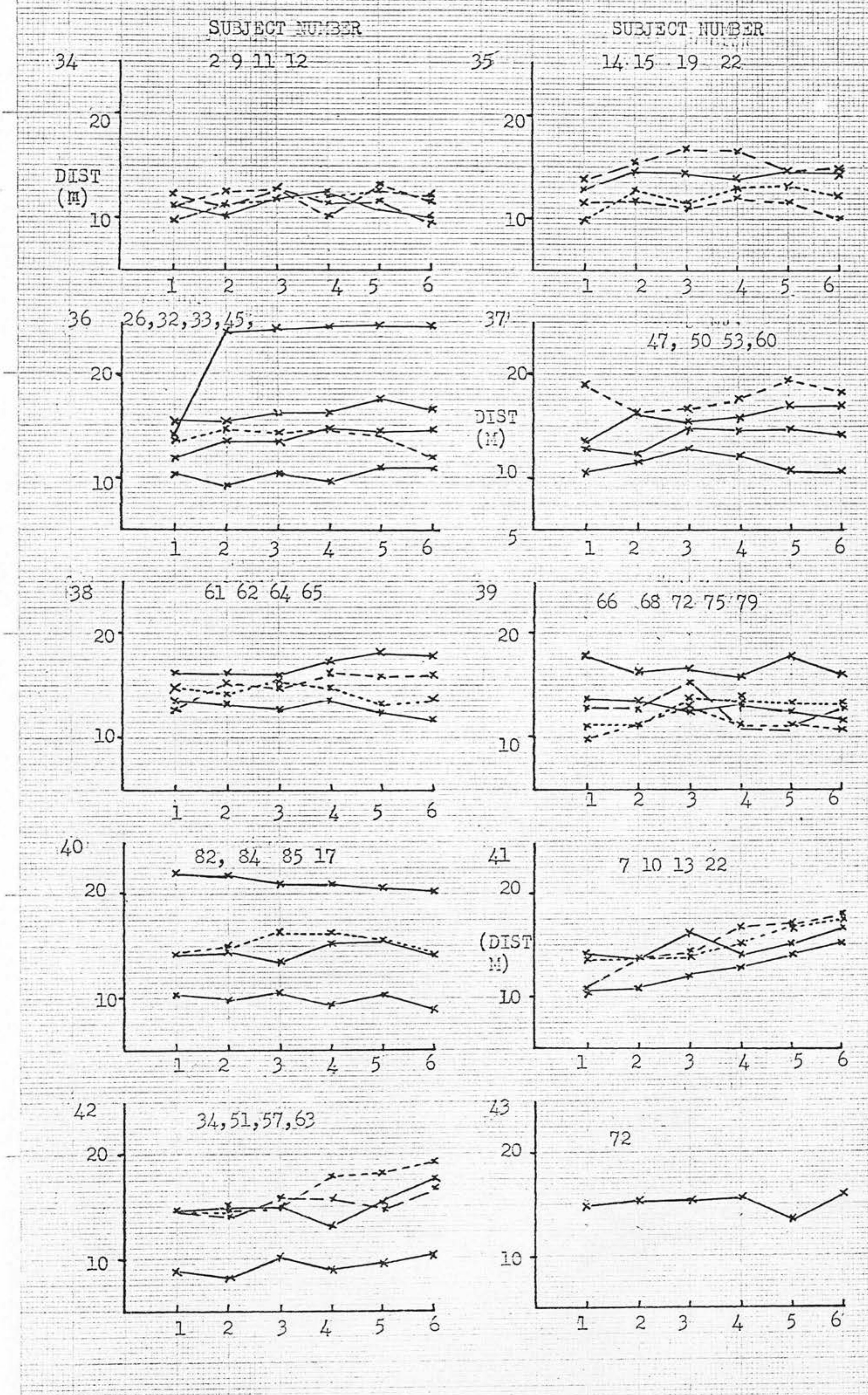
Graphs 59 -63 vertical jump distance at each attempt of subject classified as having an 'inconsistent' pattern of jumps.

Graphs 64 - 70 vertical jump distance at each attempt of subjects classified as having a 'peaking' pattern of jumps.

Graphs 71 -73 Vertical jump distance at each attempt of subjects classified as having an 'improving' pattern of jumps.

Axes Graphs 34 - 53 x axis: Basketball throw distance (m).
y axis: Attempt number.

Graphs 54-73 x axis: Vertical jump distance (m)
y axis: Attempt number.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39
66 68 72 75 79
40
82, 84 85 17
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43
72
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DIST (M)
(DIST M)
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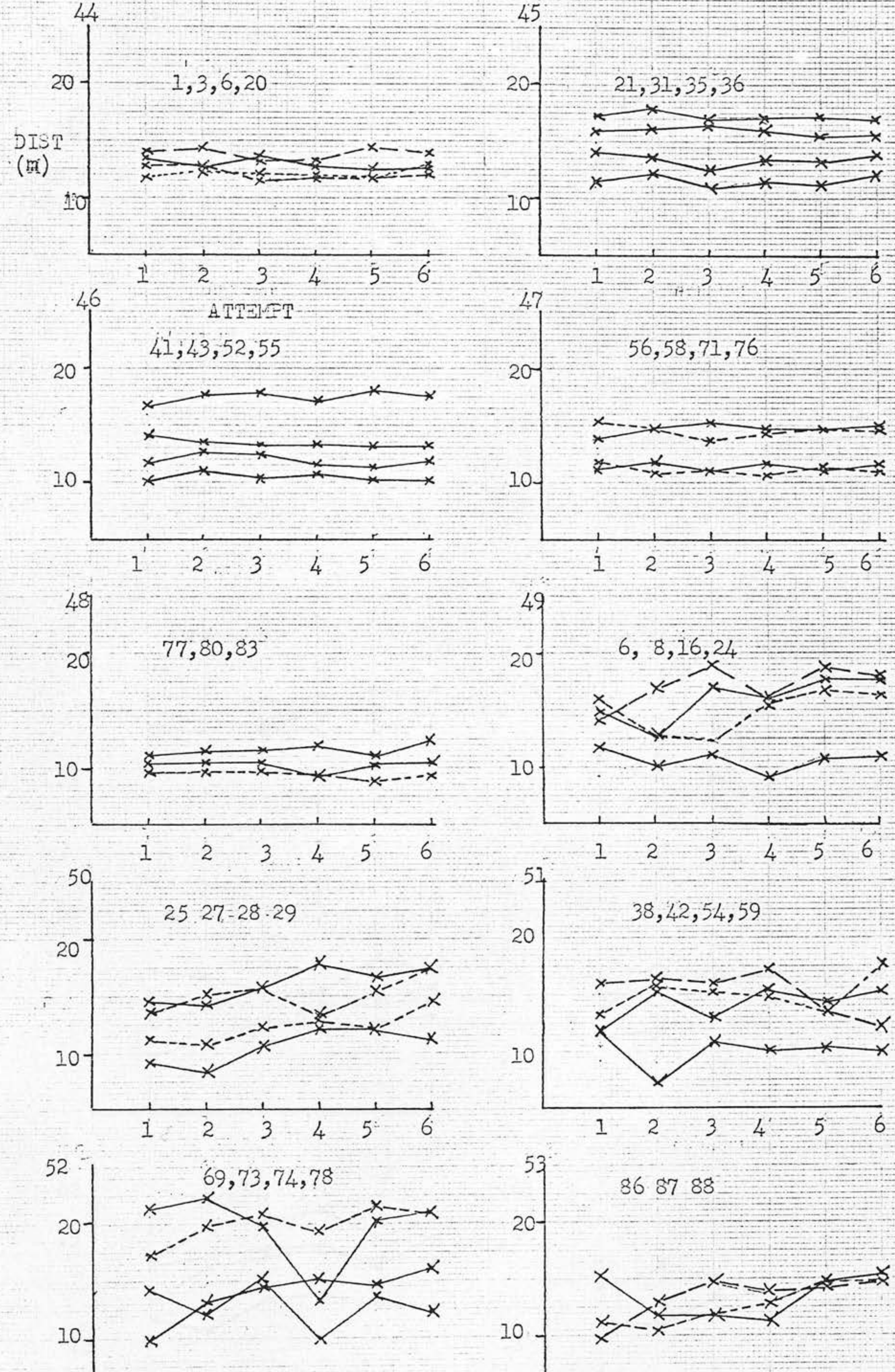
10
5
1 2 3 4 5 6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DIST (m)
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ATTEMPT
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41,43,52,55
20
10
1 2 3 4 5 6
47
56,58,71,76
20
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77,80,83
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38,42,54,59
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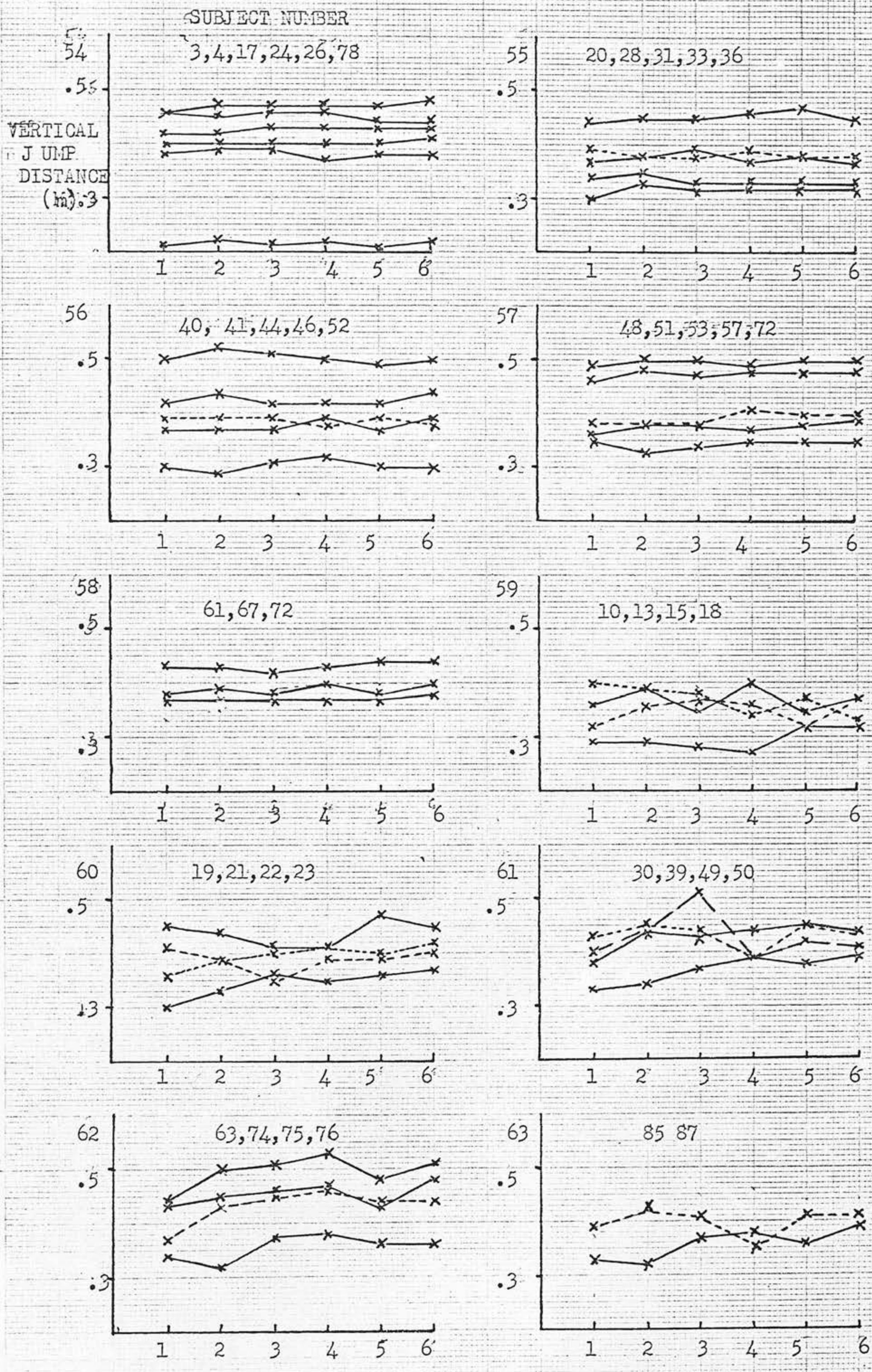
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57
48,51,53,57,72
58
61,67,72
59
10,13,15,18
60
19,21,22,23
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63,74,75,76
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.3
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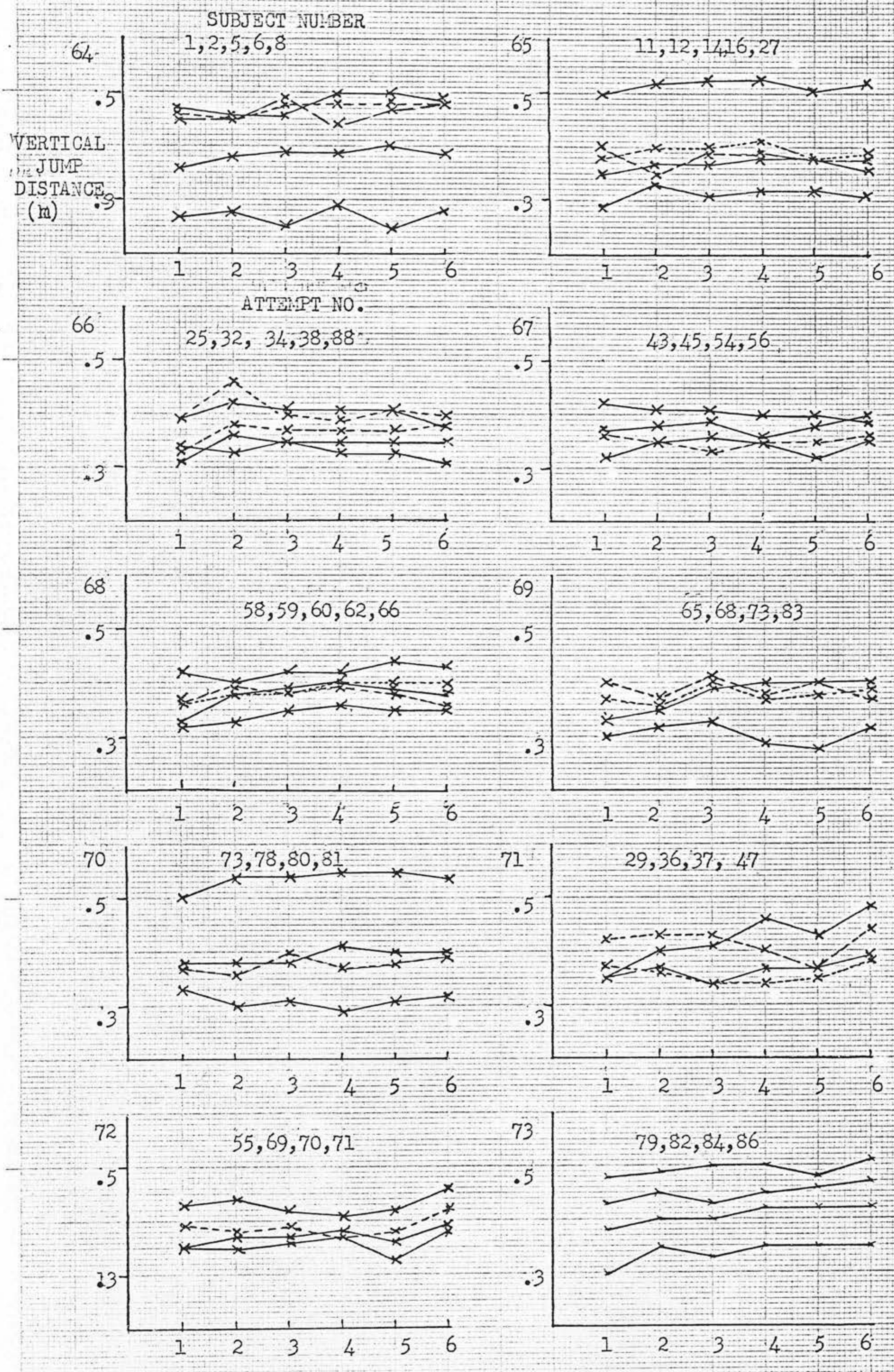
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.3
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66
25,32, 34,38,88
.5
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43,45,54,56
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.3
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68
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.3
1 2 3 4 5 6
69
65,68,73,83
.5
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73,78,80,81
.5
.3
1 2 3 4 5 6
71
29,36,37, 47
.5
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1 2 3 4 5 6
72
55,69,70,71
.5
.3
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73
79,82,84,86
.5
.3
1 2 3 4 5 6

Appendix 2. Raw data collected during the experiment.

(a) RAW DATA USED IN CONSTRUCTION OF REGRESSION EQUATIONS

SUBJECT NUMBER	AGE YEARS	HEIGHT (m)	SITTING HEIGHT (m)	ARM LENGTH (m)	WEIGHT (Kg)	POWER TEST TIME (BEST) (sec)	VERT JUMP REACH (m)	VERT JUMP HEIGHT (BEST) (m)	50m. RUN TIME (Sec)	50m SHUTTLE TIME (sec)	BASKETBALL THROW (BEST) (m)
001	20.4	1.606	0.878	.676	59.9	1.319	2.04	2.33	11.2	16.6	13.7
002	20.2	1.647	0.890	.704	57.8	1.019	2.04	2.55	08.7	14.5	12.5
003	20.1	1.640	0.891	.693	54.7	0.991	2.04	2.53	07.8	13.2	12.9
004	18.7	1.670	0.877	.722	62.7	1.096	2.16	2.64	08.7	13.8	13.0
005	20.5	1.706	0.911	.697	61.1		2.08	2.56			
006	20.1	1.753	0.973	.742	59.6	1.146	2.22	2.62	08.5	14.2	17.9
007	19.5	1.780	0.903		71.3	0.896				13.8	16.1
008	19.6	1.494	0.770	.632	47.0	0.945	1.98	2.29	08.3	13.4	16.7
009	20.1	1.622	0.899	.661	48.1	1.031	2.06	2.55	08.1	13.6	12.7
010	18.5	1.637	0.897	.680	60.3	1.061	2.11	2.51	07.9	12.9	17.3
011	19.7	1.620	0.854	.674	61.7	0.998	2.11	2.49	08.3	14.5	13.3
012	19.8	1.700	0.910	.745	60.3	1.066	2.18	2.58	08.8	14.4	12.8
013	19.3	1.766	0.909	.724	67.9	1.046	2.25	2.62	07.4	15.4	15.2
014	18.7	1.518	0.814	.634	53.0	0.968	1.94	2.35	07.8	13.5	15.9
015	19.1	1.571	0.815	.647	59.5	0.945	2.04	2.44	08.3	15.6	16.7
016	21.1	1.764	0.950	.765	66.6	0.876	2.28	2.81	07.6	13.5	19.0
017	20.2	1.585	0.862	.628	66.1	0.996	2.04	2.47	07.8	13.7	10.6
018	19.9	1.579	0.863	.651	56.9		2.03	2.35			
019	18.8	1.685	0867	.697	64.9	1.163	2.17	2.54	08.7	15.0	13.2
020	18.9	1.598	0.846	.659	61.8	1.002	2.03	2.50	08.8	12.5	14.5

continued

021	19.9	1.573	0.820	.660	54.2	1.037	2.02	2.41	07.6	11.2	16.5
022	19.7	1.632	0.869	.737	55.9	0.984	2.12	2.54	08.9	11.5	17.6
023	18.7	1.677	0.900	.695	55.7	1.006	2.11	2.58	07.7	11.4	12.1
024	19.5	1.588	0.837	.682	58.3	0.951	2.04	2.45	07.6	14.6	11.9
025	18.8	1.587	0.833	.667	61.8	1.226	2.00	2.34	09.8	13.1	12.3
026	19.9	1.662	0.888	.662	68.2	1.133	2.24	2.46	08.9	12.0	14.9
027	19.6	1.681	0.917	.698	62.4	1.047	2.16	2.49	07.1	12.6	14.3
028	18.8	1.606	0.867	.650	49.5	1.057	2.01	2.34	08.8	12.5	14.4
029	19.7	1.665	0.852	.695	63.1	1.061	2.15	2.54	08.1	12.5	17.6
030	20.8	1.594	0.867	.669	64.8	1.035	2.10	2.49	08.2	15.7	15.6
031	19.3	1,550	0.844	.654	62.5	1.092	2.00	2.39	08.5	11.8	18.1
032	19.7	1,588	0818	.710	60.7	0.909	2.14	2.56	08.3	11.7	24.7
033	19.2	1,681	0.904	.690	64.9	1.002	2.12	2.51	08.5	11.6	14.9
034	20.5	1,656	0.893	.717	56.1	0.988	2.12	2.56	07.8	11.3	17.8
035	19.4	1,569	0.828	.650	52.5	1.036	2.00	2.35	08.5	14.7	14.3
036	18.8	1,631	0.847	.686	52.0	0.938	2.05	2.53	07.8	11.0	12.3
037	19.0	1,634	0.870	.687	61.3	1.044	1.99	2.43	08.8	11.5	10.9
038	20.3	1,695	0.907	.703	70.5	1.241	2.16	2.52		16.5	15.8
039	19.5	1,584	0.839	.656	52.4		2.02	2.47			
040	20.2	1,784	0.856	.734	61.4		2.18	2.57			
041	18.8	1,624	0.870	.678	57.3	0.973	2.07	2.46	0.84	14.1	14.2
042	19.9										17.8
043	19.8	1,598		.649	56.3		2.01	2.40		11.5	11.1
044	20.8	1,690		.725	77.7		2.12	2.64			
045	20.1	1,677		.665	55.4	0.973	1.98	2.40	0.84	14.2	17.7

continued

046	19.3	1.568	0.853	.660	52.0		2.03	2.35			
047	19.3	1.572	0.840	.678	54.5	0.949	2.04	2.42	08.3	13.9	12.7
048	19.3	1.625	0.880	.705	58.9	1.003	2.09	2.48			
049	19.8	1,695	0.932	.725	72.5		2.16	2.61			
050	19.4	1.637	0.841	.693	58.0	1.021	2.06	2.57	08.0	14.4	17.0
051	19.1	1.587	0.846	.664	50.3	1.091	2.00	2.35	08.8	15.7	10.3
052	19.9	1.616	0.852	.700	52.8	0.873	2.09	2.53	08.3	13.6	12.7
053	19.7	1.675	0.874	.725	57.1	0.816	2.17	2.65	08.1	11.1	14.8
054	19.7	1.646	.927	.680	57.7	0.927	2.10	2.46	08.1	14.1	17.2
055	19.5	1.563	0.853	.647	53.6	1.014	1.97	2.36	08.5	15.1	18.1
056	18.7	1.569	0.844	.665	52.3	1.128	2.01	2.37	08.3	15.3	11.7
057	20.9	1,558	0.863	.635	54.4	0.913	1.92	2.42	07.8	14.0	19.3
058	19.4	1,567	0.862	.671	54.3	1.122	1.97	2.37	08.6	14.6	15.3
059	20.3	1,691	0.905	.730	57.4	0.911	2.18	2.57	08.5	11.6	11.7
060	18.9	1.600	0.879	.646	60.0	1.062	2.06	2.50	07.6	14.6	19.5
061	19.1	1.583	0.821	.657	52.1	1.103	2.02	2.42	08.1	15.5	13.6
062	19.9	1.531	0.856	.625	57.4	1.128	1.94	2.30	09.8	15.4	16.0
063	18.9	1.722	0.924	.741	65.5	0.924	2.23	2.71	07.8	10.6	16.0
064	19.5	1.632	0.876	.681	53.4	0.907	2.09	2.49	08.1	13.3	18.2
065	19.5	1.673	0.866	.647	56.5	0.939	2.10	2.50	08.1	14.1	14.8
066	18.4	1.517	0.849	.652	49.3	1.056	1.92	2.35	08.4	15.0	13.6
067	20.2	1.611	0.852	.693	56.6	0.964	2.08	2.52			
068	19.8	1.834	0.959	.796	75.7	1.079	2.38	2.78	08.3	14.3	17.9
069	19.1	1.575	0.832	.666	61.5	1.065	1.98	2.36	08.4	14.9	15.2
070	19.4	1.615	0.870	.700	53.5	1.083	2.06	2.48			

continued

071	19.1	1.658	0.881.	.691	59.1	0.923	2.15	2.61	07.6	14.5	11.4
072	20.1	1.621	0.869	.702	62.6	1.063	2.13	2.50	08.4	14.9	15.2
073	19.5	1.632	0.862	.684	65.1	0.978	2.08	2.48	07.8	13.8	22.4
074	20.2	1.609	0.852	.662	63.0	0.985	2.05	2.51	08.3	14.5	21.6
075	19.6	1.686	0.886	.690	64.6	1.037	2.14	2.52	08.7	15.1	12.8
076	20.4	1.700	0.907	.722	58.5	0.836	2.22	2.76	07.2	13.2	15.3
077	19.9	1.660	0.867	.664	57.0	1.045	2.10	2.49	07.1	14.3	10.5
078	19.9	1.642	0.851	.752	59.0	1.066	2.10	2.51	08.3	14.3	15.8
079	20.3	1.595	0.836	.675	66.7	1.097	2.08	2.43	08.6	17.0	13.6
080	19.4	1.802	0.919	.768	64.4	1.218	2.25	2.80	08.3	13.4	12.5
081	19.0	1.624	0.880	6.88	56.6	1.092	2.12	2.45	08.5	15. 1	16.4
082	20.3	1.576	0.852	.650	58.7	1.017	2.00	2.47	08.7	13.9	15.5
083	19.0	1.537	0.810	.618	56.5	1.161	1.94	2.27	08.5	15.2	09.7
084	19.9	1,679	0.888	.732	61.6	0.886	2.13	2.64	08.1	155.2	22.0
085	19,8	1,625	0.894	.642	62.2	1.149	2.00	2.39	08.8	14.7	16.3
086	19.3	1.561	0863	.649	54.0	10.58	2.03	2.46	08.0	14.9	15.3
087	20.5	1.610	0.873	.668	57.5	0.931	2.07	2.49	08.1	14.9	14.8
088	20.2	1.567	0.856	.677	53.0	1.014	2.02	2.40	08.4	14.5	15.4

(b) RAW DATA COLLECTED FROM 'UNMOTIVATED' GROUP

SUBJECT NUMBER	AGE years	HEIGHT (m)	SITTING HEIGHT (m)	WEIGHT (Kg)	POWER TEST TIME (BEST) (sec).
089	20.2	1.614	.871	58	
090	19.5	1.604	.865	57.4	1.269
091	19.9	1.600	.868	59.7	1.091
092	20.4	1.744	.922	74.2	1.159
093	18.5	1.644	.861	55.0	0.980
094	19.6	1.563	.841	55.5	1.079
095	20.7	1.694	.894	64.0	1.036
096	19.9	1.095	.842	58.5	1.234
097	20.4	1.627	.851	52.2	1.107
098	21.2	1.628	.850	56.6	1.074
099	20.6	1.645	.857	58.6	1.063
100	20	1.635	.861	55.8	.957
101	21.2	1.662	.890	63.1	1.074
102	19.6	1.607	.842	55.6	1.047