Chapter 4

ANALYSIS OF THE SCREENING TEST

Exploratory studies have three purposes: to discover significant variables in the field situation, to discover relations among variables, and to lay the groundwork for later ... exploratory field studies, research aimed at discovering or uncovering relations, is indispensable to scientific advance

(Kerlinger, 1973, p.406)

Introduction to Chapter

The previous chapter indicated some positive changes to the children's skill levels which may have been the result of the Gymstart program. These were evaluated through a pre and post test screening procedure. Initially, as the remedial program's primary function was to return to the children some benefit from being part of the study, there was no intent to test its efficacy. Therefore, under normal circumstances a simple statement of the difference in results to give an impression of the children's response to the program, would have sufficed. However, given the exploratory nature of this study and the interesting trends which appeared in the analysis of the pre and post test data, a variation in the planned lines of investigation developed. Following Kerlinger's assertions above, about the importance and value of the exploratory field study, a further line of enquiry in the field was pursued, in order to discover or uncover any differences between the seventeen children classified as clumsy and their peers in the normal population. A subsequent analysis of this further investigation may provide a better understanding of the clumsy child.

This chapter describes the circumstances upon which the additional investigation took place and consequently, its findings. The chapter is organised to present that description in four sections. Firstly, a background description and discussion of the further analysis undertaken on the pre and post test results, which revealed trends of interest and led to the exploration of this new line of enquiry, is reported. Secondly, the planning, context, research design, major participants, instrumentation and data analysis plan for the new investigation are described. Thirdly, the results of the analysis which emanated from this investigation are presented. The final section interprets and summarises the results of this investigation.

BACKGROUND

The analysis of the screening procedure, used as a pre and post test for the Gymstart program, was reported in Chapter 3. The initial results revealed four out of seven items showed a significant difference between trials, which can be seen from Tables 3.6 and 3.7. The data were further scrutinised for confirmation of this significance using post hoc statistical procedures. One of these procedures was in the form of a correlational analysis which revealed an interesting trend and led to this supplementary study. This section describes and discusses the results of the initial correlational analyses.

Correlation coefficients were computed on the screening procedure pre test for seven skills. The correlation matrix can be seen in Table 4.1, with the partial correlations and squared multiple R in Table 4.2

Table 4.1 : Correlation Matrix for the Screening Pre Test

	Shuttle Run	Dynam. Bal.	Static Bal.	Thrw/ Catch	Stand. Jump	Dots/ Circles	Station. Hop
Shuttle Run	1						
Dynam. Bal.	-.1508	1					
Static Bal.	.024	.1553	1				
Thrw/ Catch	-.4708	.1502	0221	1			
Stand. Jump	.0766	.0905	0589	.2704	1		
Dots/Circles	.1418	.2249	-.0242	.0374	.1190	1	
Station. Hop	.2562	-.1422	3629	-.1287	.3947	.4556	1

Table 4.2 : Partial Correlation Matrix for the Screening Pre Test (Squared Multiple R in Diagonal)

	Shuttle Run	Dynam. Bal.	Static Bal.	Thrw/ Catch	Stand. Jump	Dots/ Circles	Station. Hop
Shuttle Run	.303						
Dynam. Bal.	-.144	.284					
Static Bal.	.053	.361	.312				
Thrw/ Catch	-.489	-.089	.161	.374			
Stand. Jump	.201	.263	-.245	.418	.36		
Dots/Circles	.159	.44	-.375	.225	-.266	.426	
Station. Hop	-.009	-.434	.536	-.276	.51	.602	.605

The results of the analysis show no significant correlations (.01 level[4.1] requiring .606 for n=17) between any of the tests. Although the partial correlations shown in Table 4.2 are of little interest where the correlation matrix shows no significant relationships, the squared multiple R may be of interest as a comparison with the analysis of the results from the 'normal population' presented later in this chapter.

Correlation coefficients were computed on the screening procedure post test to see if the lack of correlation was resilient to the changes in ability. The correlation matrix for the post test can be seen in Table 4.3. and the partial correlations in Table 4.4

Table 4.3 : Correlation Matrix for the Screening Post Test

	Shuttle Run	Dynam. Bal.	Static Bal.	Thrw/ Catch	Stand. Jump	Dots/ Circles	Station. Hop
Shuttle Run	1						
Dynam. Bal.	-.015	1					
Static Bal.	-.139	.136	1				
Thrw/ Catch	-.583	.23	.205	1			
Stand. Jump	-.282	.1	.388	.419	1		
Dots/Circles	-.119	.065	-.119	.352	.073	1	
Station. Hop	.031	-.063	.198	.207	.159	.362	1

The results of the analysis show no significant correlations (.01 level requiring .606 for n=17) between any of the tests, confirming that the trend was constant.

Table 4.4 : Partial Correlation Matrix for the Screening Post Test (Squared Multiple R in Diagonal)

	Shuttle Run	Dynam. Bal.	Static Bal.	Thrw/ Catch	Stand. Jump	Dots/ Circles	Station. Hop
Shuttle Run	.389						
Dynam. Bal.	.181	.111					
Static Bal.	-.049	.133	.238				
Thrw/ Catch	-.559	.258	.042	.529			
Stand. Jump	-.046	-.015	.311	.267	.274		
Dots/Circles	.032	.047	-.257	.285	-.027	.276	
Station. Hop	.198	-.174	.241	.14	.041	.353	.239

The partial correlations and squared multiple R seen in Table 4.4 are presented for reasons stated previously.

4.1 A level of significance of .01 was used for the correlations to provide some protection against a type 1 error.

The ramifications of finding no correlation between what can be considered related test items are important and have implications both theoretically and practically. These results suggest that clumsy children's abilities may be task-specific and that they are not able to transfer ability (possibly learning) from one task to another. This is consistent with findings in studies on other learning difficulties (Bjorklund, Muir-Broaddus & Schneider 1990; Garner 1990; Ashman, van Kraayenoord & Elkins 1992), and although Revie (1991) found that poorly coordinated children were inclined to be task-specific and Revie and Larkin (1993b) found task-specific intervention to be successful for clumsy children, as yet this feature has not been confirmed in a substantial number of studies with children experiencing movement difficulty. As a consequence of this finding it was decided to extend the scope of this study to explore further these findings in an attempt to confirm that this trend was particular to the study's population and not to the general population of six-to-eight year olds. The next section describes the design of this post hoc investigation.

DESIGN OF THE SUPPLEMENTARY STUDY

In the previous section, an important research issue was identified in the findings. This led to the identification of a further research question, namely:

(E) Do clumsy children exhibit more of a tendency to be task-specific in their motor abilities than normal children?

This section outlines how a supplementary study was set up by describing the planning, context, research design, major participants, instrumentation and data analysis plan for the new investigation.

PLANNING AND CONTEXT FOR THE RESEARCH

Planning for this further study needed to encompass a number of issues. Firstly, the purpose of the investigation, generated by the research question, was principally to make comparisons of a population of clumsy children with a normal population. Secondly, the planning process needed to consider the limitations and constraints that were placed upon it by the various circumstances surrounding the principal study. The context and setting was within that established in Chapter 2 and the background information provided in this chapter.

Limitations and Constraints

The findings which initiated the new investigation focused the line of research on to a fairly narrow issue. The focus of interest from the statistical analysis of the screening pre test with the Gymstart group, decided which data would be collected and how they would be analysed. The normal population selected would be tested using the screening procedure test items and the results would be analysed for correlations. This dictated the instrumentation and determined the data analysis plan.

The timing of the supplementary study, in relation to the final stages of the main study created a limited time frame for the investigation. This dictated expediency in the collection of the new data and meant that the population sample should come from one school to minimise time in administering and negotiating for the conduct of the tests. In selecting a single school, a larger school was seen as highly desirable as it would be more likely to produce an appropriate sized sample, matched for age and gender with the Gymstart group. As events transpired the largest primary school in the local area did not have children in the main study, and as they agreed to participate in the testing procedures, they were ostensibly self-selected. The number of children in the relevant age groups at this school determined the sample size.

The school providing a new population of children to be tested would impose specific limitations and constraints, similar to previous schools' requirements but not necessarily the same. The school asked for as little disruption as possible to the normal program. Therefore, the children were withdrawn individually from class on a rotational basis, in similar fashion to the original screening in the schools to select the Gymstart children. In addition, teachers preferred that all children, in any given class, be tested regardless of their suitability for inclusion in the sample, to alleviate any perceived discrimination. This meant that the sample was selected after testing all children in years one and two. As a consequence, the testing included the following: children who were deemed to have motor difficulties; children who experienced other disadvantages which would preclude them from the sample; or, were not the right age for matching with the Gymstart group. However, only children who would not have been referred to the Gymstart program initially (had this school been a feeder to that program) and were the correct age for matching, formulated the population from which the sample was drawn. One advantage of screening all children was that those identified as having motor learning difficulties by the teachers were able to be classified by the testing for future referral. This gave the school, the teachers and the children some return for participating in the testing.

The limitations and constraints placed on the supplementary study dictated expediency in its implementation, which determined a single school from which to take the sample. This, in turn, decided the sample size. The nature of the findings in the main study directed the form of data collected and the methods of collection. The advantage gained by working within these limitations was that the expediency needed in carrying out the data collection, created by necessity increased efficiency in planning and implementation. The short time frame for completion of the supplementary study benefited the main study greatly and caused minimal disruption to the school involved in exchange for some identifiable returns.

RESEARCH DESIGN OF THE SUPPLEMENTARY STUDY

The design took into account the limitations and constraints described previously, as well as issues which emerged from the main study. Essentially, an exploratory field study approach was adopted, with a plan to report and analyse the results statistically, mirroring the analysis which triggered this line of enquiry. This would provide further support for the descriptive analysis presented in Chapter 3 and additional quantitative analysis in support of planned data treatments to be presented in Chapter 5. In adding this to the multiplicity of data and approaches to analysis already established, a further contribution to the multi-dimensional approach of the main study was made.

Overview

The study was conducted over a period of about six weeks. There were three phases in the study and these were very similar to those for the screening procedures in the schools for the main study, except that in the supplementary study there was only one school involved. Documentation and letters to the school, teachers and parents followed closely that used initially in the main study, with slight amendments, which are described in appendices referred to in Chapter 2. In summary, the phases for the supplementary study were as follows:

• Phase 1 - After the participating school was selected, an initial letter was sent to the principal, to request permission to screen children for motor dysfunction in his school. Once permission was granted, guidelines for teachers on identifying children they thought were showing signs of motor difficulty were provided. Teachers then submitted the names of children they thought may fit the criteria. Although these children were tested they were excluded from the population sample. Letters informing parents of these procedures and seeking their permission to test children, were distributed through the school principal.

• Phase 2 - All children from years one and two were screened for motor dysfunction using the screening procedure which was developed for the main study. The Research Director and a research assistant who had participated as an instructor in the Gymstart program assessed the children.

• Phase 3 - The population for the sample was selected by: excluding the children who would be referred ordinarily to the Gymstart program by teachers; and, randomly selecting the desired number of children matched for age and gender. The data set was then analysed.

PARTICIPANTS AND INSTRUMENTATION

There were two major groups participating in the program, the children and those undertaking the administration of the testing. Although the teachers involved had some influence on the success of the screening program, the two groups described below are those who were involved most directly.

The Children

Over 100 year one and year two children were tested using the screening procedure. Dictated by the number of children that were available, an optimum number of children to be used for the sample population was set at 68. This sample size was determined by taking the largest multiple possible of the size of the Gymstart group (n=17), which would still give exact proportions of age and gender groups. e.g., the number of six year old boys in the Gymstart group was proportionally the same in the normal sample population.

The Testers

The research director (described in Chapter 2) organised, coordinated and conducted the testing. A research assistant, co-opted to shorten the time needed and hence the disruption in the school, also took part in the testing program. The research assistant was involved previously with the Gymstart testing and was a post-graduate student in physical education.

Instrumentation

The diagnostic screening procedure, used both for pre and post test analysis in the Gymstart program, was utilised for the testing This screening procedure was selected as it was its analysis that initiated the supplementary study. The test battery consisted of the following items: a stationary hop test; judgement of throw and catch; a timed static balance; dynamic balance; standing broad jump; running speed and agility - shuttle run; hand-eye dominance determination; and fine motor hand-eye coordination - placing dots in circles in a specified time. The items were scored and recorded in the same way as for the Gymstart program. Extensive details of the procedures are described in Chapter 2.

DATA ANALYSIS PLAN

The children who would not be able to be matched with the group involved in the main study, or would have been candidates for the Gymstart program, were excluded from the sampling. There were 87 children (cases) who had been tested on seven items giving quantitative scores that could be matched for age and gender. Each age/gender grouping, e.g., six-year-old girls, was then selected randomly until the groupings within the sample matched proportionally the Gymstart age/gender groupings.

The comparative nature of the supplementary study determined the data analysis should match that which stimulated interest in the new line of enquiry. This meant that the new data would be analysed for correlational trends, in the same way as data from the Gymstart group was analysed. Therefore, analysis of the data, taken from new sample population, was undertaken in the same way as that described earlier in this chapter.

RESULTS OF THE SUPPLEMENTARY STUDY

This section compares the two groups involved in the supplementary to establish to what extent the populations were differed from each other, and how they differed in correlations across the test items which were used in the analysis.

COMPARING THE GROUPS

In comparing the Gymstart group with the normal population sample in descriptive terms it is evident that the two groups are different. Figure 4.1 compares the mean scores for each group on each of the seven screening test items, using the pre test as the most appropriate comparative results for the clumsy group as there would be no influence from the program.

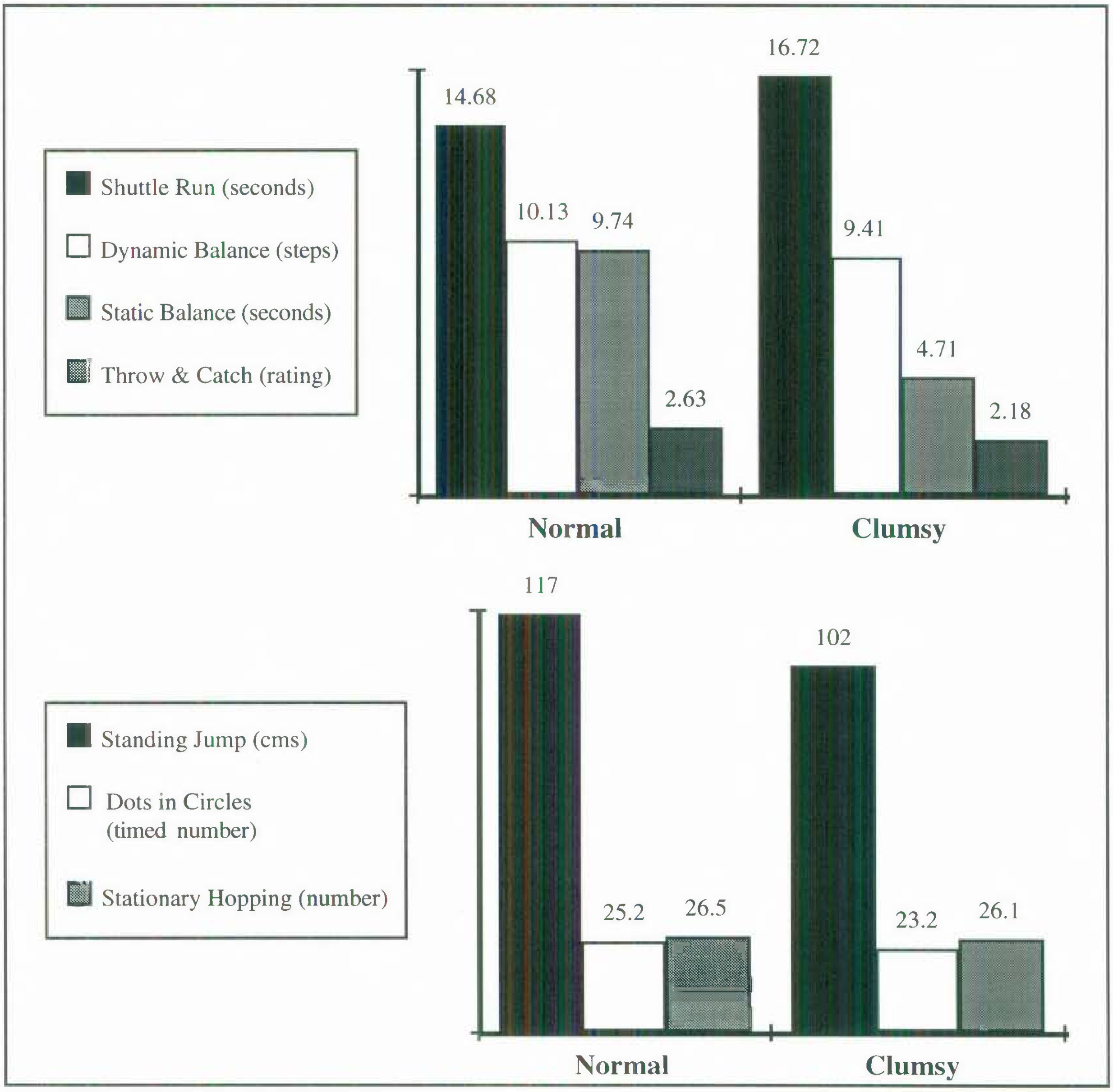

Figure 4.1 : Comparison of Normal Group with Gymstart Group on the Screening Test

In practical terms, the differences in mean running speed (shuttle run) of 2 seconds between the groups is considerable and would move the percentile ranking for this item in any given age and gender group upwards in the order of 50 points on the norm tables (CAPHER 1980). Similarly, the difference between mean jumping measures (standing jump) would see the normal group placed higher on the percentile rankings, on average about 30 points (CAPHER 1980). In both of these examples the clumsy group are placed, in general, below the 20th percentile and the normal group between the 35th and 65th percentile, depending on age and gender. This suggests that the normal sample is sufficiently different than the Gymstart group and representative of a normal population.

These descriptive and practical assertions about differences are supported by statistical evidence from quantitative analysis of the relevant data. The 68 'normal' children were compared with those in the 'clumsy group, using MANOVA procedures with the seven screening test items as the dependent variables and the two groups of children as levels of independent variable. The MANOVA assumptions of linearity were checked using scattergram plots, and assumptions of univariate normality using normal probability plots and Z-score values of cell-wise skewness and kurtosis indices. These proved satisfactory but the univariate assumptions of dispersion were found not to be supported for the following items:

- Static Balance (Bartlett-Box F = 6.4, df = 1, 6317, p = .011)
- Throw and Catch (Bartlett-Box F = 8.8, df = 1, 6317, p = .003)
- Standing Jump (Bartlett-Box F = 11.8, df = 1, 6317, p = .001)

Consequently, the multivariate test of homogeneity of variance/covariance matrices using the Box M test proved not to be satisfactory. However, given that the Box M test is known to be extremely sensitive to moderate departures from these homogeneity assumptions, following the advice of Hair et al. (1995), the MANOVA procedure was retained.

The multivariate effect on the composite variable was highly significant according to the Pillai, Hotellings and Wilks criteria (F = 7.96, df = 7,77 p < .001). The univariate results indicated significant differences in favour of the 'normal' group with respect to shuttle run, static balance, throw and catch, and standing jump, but not for dynamic balance, dots in circles or the hopping task, as indicated in Table 4.5.

Table 4.5 : Screening Test Results and Analysis Comparing Normal and Clumsy Group

Test Item	Clumsy Group Mean	Normal Group Mean	F Ratio (df 1, 83)	Level of Significance	ETA Square
Shuttle Run	16.724	14.678	44.971	.000*	.35141
Dynam. Bal.	9.412	10.132	.88282	.35	.01052
Static Bal.	4.706	9.735	15.945	.000*	.16115
Thrw/ Catch	2.176	2.632	7.7477	.007*	.08538
Stand. Jump	102	117.29	9.9329	.002*	.10688
Dots/Circles	23.176	25.235	2.7022	.104	.03153
Station. Hop	26.059	26.5	.0102	.92	.00012

* significant at the 0.05 level

CORRELATIONAL ANALYSIS

Correlation coefficients were computed on the screening procedure data from the sample population of normal children. The correlation matrix can be seen in Table 4.6, which shows significant correlations (.01 level requiring .314 for n=68) between some of the tests. The partial correlations and squared multiple R can be seen in Table 4.7.

Table 4.6 : Correlation Matrix for the Screening Test with the Sample Population of Normal Children

	Shuttle Run	Dynam. Bal.	Static Bal.	Thrw/ Catch	Stand. Jump	Dots/ Circles	Station. Hop
Shuttle Run	1						
Dynam. Bal.	-.108	1					
Static Bal.	-.262	.737*	1				
Thrw/ Catch	-.332*	.307	339*	1			
Stand. Jump	-.647*	.089	.262	.357*	1		
Dots/Circles	-.34*	.232	.227	.207	.372*	1	
Station. Hop	-.327*	.145	.192	.281	.303	.183	1

*Significant at the 0.01 level

The highest correlation was between Dynamic Balance (Dynam. Bal.) and Static Balance (Static. Bal.) with a correlation coefficient of .737 (Table 4.6) and partial correlation of .716 (Table 4.7), proving a significant direct relationship between these two aspects of motor ability. Similarly, Leg Power (Stand. Jump) and Running Speed (Shuttle Run) were significantly correlated with a coefficient of - 647[4.2] (Table 4.6) and the partial correlation of -.511 (Table 4.6).

4.2 Negative correlations with running will be the inverse of the norm as a faster time (which is positive) would

Table 4.7 : Partial Correlation Matrix for the Screening Test with the Sample Population of Normal Children (Squared Multiple R in Diagonal)

	Shuttle Run	Dynam. Bal.	Static Bal.	Thrw/ Catch	Stand. Jump	Dots/ Circles	Station. Hop
Shuttle Run	.459						
Dynam. Bal.	.081	.578					
Static Bal.	-.106	.716*	.591				
Thrw/ Catch	-.092	.142	.065	.237			
Stand. Jump	-.511*	-.159	.146	.167	.481		
Dots/Circles	-.125	.164	-.04	.005	.205	.194	
Station. Hop	-.147	.03	.017	.146	.083	.033	.153

*Significant at the 0.01 level

Other significant correlations between abilities, indicated in Table 4.6, suggest that their relationships were less direct than this, with none of these emerging as significant in the partial correlations seen in Table 4.7. The Squared Multiple R shown in the diagonal readings of Table 4.7 are higher for Dynamic Balance (Dynam. Bal.), Static Balance (Static. Bal.), Leg Power (Stand. Jump) and Running Speed (Shuttle Run) than those in Tables 4.2 and 4.4, for the same items. This also suggests that there are differences in the two groups based upon the items in the screening procedures.

DISCUSSION AND INTERPRETATIONS

Intuitively, a relationship between abilities such as static balance and dynamic balance or leg power and running speed might be expected. Even though some of the relationships in the normal group may not be linked as logically or directly, these two pairings have a rational explanation of their relationship in practical terms. Some of the abilities which correlated initially and then failed to exhibit significance in the partial correlations were able to be explained in a practical sense, e.g., hopping has a obvious link with running.

The lack of correlation between motor abilities of children in the Gymstart group (albeit a small sample) compared with abilities which seem to be related in the normal group, suggest that clumsy children differ in this important aspect from the normal population. The most far reaching interpretation of this finding is that clumsy children lack the ability to transfer skill in one aspect of motor function across to a closely related aspect. This has extensive ramifications for the teaching and learning strategies which are adopted for children with motor difficulty, in that these strategies need to consider this lack of transfer. Further

reduce the magnitude of the data.

investigation of this finding is required, particularly with larger numbers, to confirm that this trend would remain robust in different settings.

The findings of this supplementary study add to the descriptive information gleaned from the results in Chapter 3 about the characteristics of clumsy children. Furthermore, they answer the additional research question posed earlier in this chapter, i.e.:

(E) Do clumsy children exhibit more of a tendency to be task-specific in their motor abilities than normal children?

The answer being that there is a strong likelihood of clumsy children being more task-specific in their motor abilities than normal children. Assuming that this is the case, then the implications for instructional methods adopted for these children are substantial. In addition, the information gained adds to knowledge about the characteristics of clumsy children, the quest for which is one of the underlying research themes of this study. This aggregation of information regarding these characteristics continues in the next chapter with a statistical analysis of the data from the principal study and in Chapter 6 with in-depth case analyses.

Chapter 5

CLUSTERING VARIABLES AND SUBJECTS

Cluster analysis provides an alternative method for reduction of multivariate data to standard factor analysis when applied to variables. When applied to subjects, cluster analysis serves to produce a typology of homogeneous clusters of individuals which can be discriminated across the variables used to relate the individuals to each other. The clusters can then be validated by relating them back to other relevant variables not explicitly used in the clustering process.

(Cooksey 1984, p. 42)

Introduction to Chapter

The previous chapters have indicated a number of trends emerging from the data, which may help to characterise the clumsy child and, in so doing, provide answers to the research questions. This chapter describes a further statistical analysis of a selected proportion of these data used to profile the group in Chapter 3. The chapter is organised to present that analysis in four sections. Firstly, a description of the analytical technique to be used (i.e., cluster analysis) is discussed. Secondly, the results of the cluster analysis, applied to the variables deemed appropriate for the task, are provided. Thirdly, the results of the cluster analysis which groups the children in the study into sub-types, is reported. Finally, a summary discussion links the findings of this chapter.

Before commencing the analysis it should be stressed that this thesis is essentially qualitative in nature and is characterised by a small sample size with an extensive set of data relating to each subject, i.e., the main study is 'data heavy and sample short'. Consequently, the quantitative treatment of the data presented in this chapter is, of necessity, exploratory and classificatory in nature rather than influential in intent. Notwithstanding this constraint, the quantitative analysis reported in this chapter complements the qualitative treatment of the data in Chapter 3 and the supplementary study presented in Chapter 4. This allows the identification of some fruitful lines of enquiry and provides methodological triangulation to improve the overall validity of the findings, as indicated by Cooksey's last sentence above.

CLUSTER ANALYSIS

The aim in taking a multiplicity of measures on the children, was to secure sufficient data to facilitate a deeper response to the research questions. The measures of the various forms of data were compiled and computed as indicated in previous chapters. These data were then subjected to cluster analysis in order to establish whether the children could be grouped into types according to the results of the testing. The purpose was to identify aspects of the measured characteristics, and of the children themselves, where grouping together on the basis of relationships was of value in answering the research questions. Moreover, it can be argued that clumsy children fall into more homogeneous sub-types when grouped on the basis of a large number of measures and that those measures themselves can be reduced to a smaller set of indicators. The object of this chapter is to extend the scope of Chapter 3, by applying a selected analytical technique - cluster analysis - to the variables. The first research question, i.e. (A) Is there a set of identifiable features which are common to clumsy children?, has to a large extent been answered in the last two chapters. The results of the cluster analysis in this chapter aims to address subsequent research questions, namely, the question which leads on from question (A):

(B) How do the identified features group together in terms of the capacities and competencies of clumsy children?

and the subsequent question :

(C) Do clumsy children group together in more discrete sub-types based upon these identifiable features?
- If so, what are the characteristics of these groupings and/or which features show prominence in formulating the groups?

A description of definitive sub-types and more robust distinguishing features could be of great value in the identification of clumsy children. For example, identifiable general features or specific characteristics in sub-types could provide a firm foundation for teacher referral to more specialist help than is currently the case. This is because the definitions of clumsiness and/or the procedures used for screening motor difficulties are either non-existent, 'ad hoc' or based on too wide a variety of interpretations and descriptions of the attributes of the children involved. Knowledge of stable sub-types and predictive indicators could help in the construction of systematic screening and identification procedures.

The identification of sub-types and grouping of characteristics could be attempted by means of the three statistical techniques, i.e., discriminant analysis, cluster analysis and factor analysis (Hoare 1991). It is not within the scope of this study to present an account of the complexities of each of these techniques. Rather, the reasons for the selection of one technique over the others and a brief description of the selected technique, which enable an understanding of the essential procedures behind the construction of the various forms of data into groupings, are given.

To commence the discussion, two definitions are required to explain how the data were viewed. Each selected measured parameter was designated as a variable and each child measured was designated as a case. There were seventeen variables and seventeen cases.

Both cluster analysis and factor analysis use correlation coefficients to group cases or variables together (Burton 1971), whereas, discriminant analysis allocates a weight to the variable which indicates its predictive value in order of importance (Cooksey 1984). Multiple discriminant analysis requires that independent variables be measured at least on an interval scale, and that each cell of the design contain at least as many cases as there are variables (Tabachnick & Fidell 1989). In the present study, as the level of measurement of the variables was ordinal (mainly percentile rankings) and there were insufficient cases (n=17) for the number of variables, multiple discriminant analysis was rejected as an inappropriate analytical technique. The value of discriminant analysis will be important in subsequent studies where initial predictors may be identified and larger groups of children assessed. However, the technique is not appropriate here.

This meant that the choice narrowed to a decision between factor or cluster analysis. Both of these analyses can be used with ordinal data, i.e., be applied to the percentile rankings used in this study. However, like discriminant analysis, factor analysis has more stringent assumptions which could not be met by this sample. In particular, Tabachnick & Fidell (1989) recommended a minimum of five cases per variable. Therefore, as it is virtually assumption free (Cooksey 1984), cluster analysis was selected as the most appropriate technique. Like discriminant analysis, the factor analysis technique is likely to play a more important role in research generated as a consequence of this study.

Cluster analysis works broadly by grouping variables or cases into clusters, such that they are more similar to each other than they are to variables or cases in other clusters. The characteristics of cases are analysed and clusters determined on the basis of maximum distance between clusters and minimum distance within clusters. Cluster analysis reduces the number of variables or cases into smaller groups. This enables the observer to identify more easily the nature of a condition, such as clumsiness, or the characteristics of a group of cases based on a set of variables. Cluster analysis is often used in the formation of taxonomies or classification of disorders (Cooksey 1984). It has been used in identifying sub-types of clumsy children (Hoare 1991) and classifying learning disabled children in terms of motor function (Miyahara 1992). The major advantage of this technique, as mentioned in the opening quotation to this chapter, is that the results of the cluster analysis can be validated and explained in conjunction with other relevant information, e.g., the descriptive data presented in Chapter 3. This is the principal reason for selection of this analytical technique.

Cluster analysis is a fairly simple method of analysing a set of multivariate data. However, the results of cluster analysis must always be interpreted with caution and on the understanding that it is an exploratory procedure. The same data subjected to different forms of cluster analysis may field radically different clusters (Aldenderfer and Blashfield 1984). Although there are guidelines that are useful in selecting appropriate procedures, ultimately the researcher must be convinced that the resultant clusters make sense, that is, they have face validity (Everitt 1981). This requirement brings difficulties also in circumstances where the choice of variables and their hypothesised groupings cannot be derived either from theory or trends evident in the research literature. In these circumstances, a useful strategy is to first factor analyse the data so as to reduce its dimensionality. In addition, this procedure derives variables that do not pose multi-collinearity problems and can be used to compute similarity measurements between cases. In the present study, however, there were insufficient cases to adopt this strategy.

An additional consideration is that the variables taken into the analyses have reasonably high bivariate correlations, as indicated in Appendix 12 by the correlations across cases. Essentially, interpretation of the analysis is further complicated by the implicit weighting of these variables. Notwithstanding these difficulties, being driven by exploratory intentions, the data were subjected to a variety of cluster analysis procedures. Because of the nature of the present study, interest focussed on identifying corresponding patterns across variables and cases rather than on assessing the absolute magnitude of differences between variables and cases. Similarity was represented by correlational and not by distance or association measures (Hair et al. 1995). Hierarchical procedures were used in preference to K-means techniques because the data set did not contain outliers that could produce artificial results.

The procedure which yielded the most interpretable clusters was the single linkage algorithm using gamma coefficients (Cohen & Holliday 1979; Lorr 1983) as similarity measures. The single linkage procedure initiates clustering by searching the similarity matrix for the two most similar entities to form the first cluster. On the second pass (i.e., step in the procedure) the next two most similar entities are joined, where entity now refers to clusters and cases. This method has a tendency to produce long, chained clusters (Aldenderfer and Blashfield 1984) and therefore, is often less favoured than Ward's complete linkage and average linkage methods (Everitt 1981; Lorr 1983) that produce tighter clusters. Nevertheless, in this study the single linkage method yielded clusters that were interpretable in terms of expected relationships between variables.

CLUSTERING THE VARIABLES

The cluster analysis, based upon seventeen variables, produced clusters which can be seen in Tables 5.1 to 5.4. The step by step process in the cluster analysis is recorded in Appendix 15 and a graph of the inter-cluster distances at each of these steps can be seen in Figure 5.1. The clusters in Tables 5.1 to 5.4 are determined by reversing the presentation of the results of the step by step procedure shown in Appendix 15. Therefore, the two cluster solution is derived from step 15 (Table 5.1), the three clusters from step 14 (Table 5.2), etc. For reasons explained subsequently, clustering stopped at five clusters and the one cluster solution corresponding to step 16 is of no value, as it is merely the cluster formed by the whole group.

PATTERNS EMERGING

In terms of usefulness for the study, there are two main areas of interest in the analysis of the clustering in the variables, namely: the clusters of variables into like groups, at a stage both statistically meaningful and practically useful; and, sets of variables which join either together early in the clustering process or remain unattached until very late in the process.

Groups of Variables Formed by the Cluster Analysis

The point at which groups can be identified as important or forming an appropriate number of groupings, can be determined both practically and statistically. For practical purposes the **maximum** useful number of groups in this study was set at five. Statistically, the number of clusters can be determined where there is an obvious change in the magnitude of relative distances at steps in the clustering process. These changes can be identified, if the inter-cluster distances are graphed and any sharp deviations (known as 'elbows') in the curve, are noted. Figure 5.1 shows the curve derived from the cluster analysis for the variables and the vertical lines depict 'elbows' in the curve. Using the practicality criteria for selection of the number of clusters in conjunction with this statistical procedure, step thirteen, or the four cluster solution, would seem to be the most valuable to select.

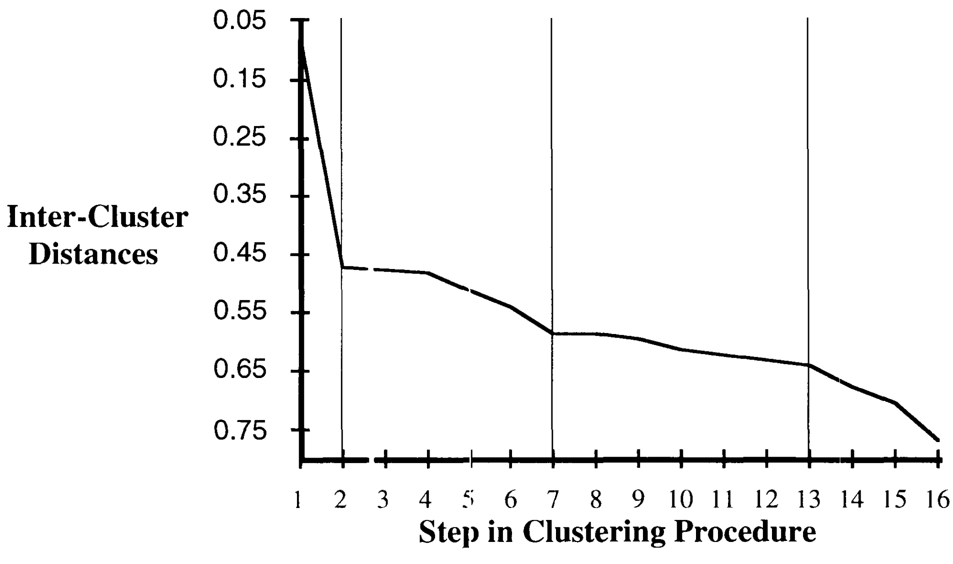

Figure 5.1 : Relative Distances Between Clusters at each Step[5.1] in the Procedure (for clustering variables)

The emerging pattern at the point of interest, both statistically and practically, therefore, starts at step twelve, being at the set maximum and occurring just prior to the selected four cluster

5.1 The number of clusters formed at each step is established in reverse order to the numbering of steps themselves, i.e., one cluster at step 16, two clusters at step 15, etc.

solution. Table 5.1 shows the established clusters of most physical capacity parameters (Cluster 1) and all self-concept parameters (Cluster 2).

Table 5.1 : Clusters of Variables from Analysis at Step Twelve (5 Clusters)

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
1. Weight 2. Height 3. Relative Sitting Height 4. Leg Power **6. Speed* 7. Stamina*** **8.Upper Body Strength*** 16. Flexibility 17. Brachial Index	11.Peer Relations Scale 12.Physical Ability Scale 13. Physical Appearance Scale 14. General Self Scale	15. Neuromuscular Development Index	10. Crural Index 9. Skinfold Measure	5. Abdominal Strength

last to join the cluster

The variables moving to form a larger cluster at step twelve joined Cluster 1, being typical of one of the two formulating patterns throughout the process of clustering (see Appendix 15). The other pattern, evident prior to step twelve, was that the self-concept variables were associating gradually as one. With the self-concept cluster complete, changes at step thirteen concerned the physical capacities cluster. Abdominal strength joining cluster one is the only change to the formation, shown in Table 5.2, below.

Table 5.2 : Clusters of Variables from Analysis at Step Thirteen (4 Clusters)

Cluster 1	Cluster 2	Cluster 3	Cluster 4
1. Weight 2. Height 3. Relative Sitting Height 4. Leg Power **5. Abdominal Strength*** 6. Speed 7. Stamina 8.Upper Body Strength 16. Flexibility 17. Brachial Index	11. Peer Relations Scale 12. Physical Ability Scale 13. Physical Appearance Scale 14. General Self Scale	15. Neuromuscular Development Index	10. Crural Index 9. Skinfold Measure

last to join the cluster

This migration to cluster one continued with two more like parameters moving at step fourteen. The previously paired (at step nine) variables of skinfold and crural index joined the rest of the physical capacities (see Table 5.3).

Table 5.3 : Clusters of Variables from Analysis at Step Fourteen (3 Clusters)

Cluster 1	Cluster 2	Cluster 3
1. Weight 2. Height 3. Relative Sitting Height 4. Leg Power 5. Abdominal Strength 6. Speed 7. Stamina 8.Upper Body Strength **9. Skinfold Measure*** **10. Crural Index*** 16. Flexibility 17. Brachial Index	11. Peer Relations Scale 12. Physical Ability Scale 13. Physical Appearance Scale 14. General Self Scale	15. Neuromuscular Development Index

last to join the cluster

The interesting trend shown by Table 5.4 is that NDI remained solitary while the self-concept group joined the physical capacities group.

Table 5.4 : Clusters of Variables from Analysis at Step Fifteen (2 Clusters)

Cluster 1	Cluster 2
1. Weight 2. Height 3. Relative Sitting Height 4. Leg Power	15. Neuromuscular Development Index
5. Abdominal Strength 6. Speed 7. Stamina 8.Upper Body Strength	
9. Skinfold Measure 10. Crural Index **11. Peer Relations Scale***	
12. Physical Ability Scale* 13. Physical Appearance Scale*	
14. General Self Scale* 16. Flexibility 17 Brachial Index	

last to join the cluster

The clustering of variables saw Flexibility and Brachial Index form the nucleus of a group that was to become the physical capacities cluster at step 12 and it remained exclusive to physical capacities until step 15. Appendix 15 shows the gradual migration of anthropometric measures into this cluster until mid-way through the process. Fitness parameters which had remained independent or associated into groups, then began to migrate to the physical capacities cluster along with the anthropometric parameters. A similar trend of gradual association occurred with the self-concept indicators. This meant that, Physical Appearance and General Self, associated at step 2 with the other two like variables, joined this cluster during the process to provide a discrete group by step 12. The self-concept cluster remained exclusive until step 15.

Individual and Paired Variables

Analysis of Appendix 15 and Tables 5.1 to 5.4 shows the variables of flexibility and brachial index were the first to pair together in the clustering process (Appendix 15). Neuromuscular Development Index (NDI) remained unattached until the last step in the process (Table 5.4). With flexibility and brachial index forming the basis of the cluster, which at step fourteen (Table 5.3) became the group of variables containing only physical capacity parameters, rather than the self-concept or the NDI. The NDI remained the most detached of the variables, being the last to be clustered at the final step.

A similar trend can be seen in the second pair of variables to affiliate at step two (see Appendix 15) and the second last individual variable to be grouped with others. Physical appearance and general self variables formed the basis of the cluster, which at step eleven became the group of variables containing only self-concept parameters and they remained clustered separately until the penultimate step in the process (see Tables 5.1 to 5.3). Abdominal strength remained the second most independent of the variables, being absorbed into a cluster at step thirteen.

OVERVIEW

The four cluster solution provides confirmation that the NDI is a distinctive individual indicator in this group and that the results of the self-concept scales are, as expected, closely related. The major changes in using the four cluster solution, rather than the observation of trends in the analysis, is that crural index and skinfold become a paired set of variables (at step nine) which are last to join the physical capacities group, i.e., group one. Their association cannot be explained easily, even though they can both be considered as physical capacities, as they differ in indicating like characteristics. In fact, the significance of this pairing, and the disinclination to join other variables which are associated strongly until late in the analytical process, is without obvious explanation and may well be an aberration of the statistical technique, and/or reflects under-sampling of the population.

However, it would be expected that variables measuring cognate dimensions would cluster together. The results of the cluster analysis have, to a certain extent, vindicated this, in that it has clustered like parameters together. The major discriminating factor to obviate the phenomenon of a statistical artefact, would be to highlight trends as important only if they appear consistent with, and can be explained by, the other descriptors used in the study. Therefore, with this as an overriding consideration this part of the analysis can only suggest the first three variables of flexibility, brachial index and NDI, as useful distinguishing features and possible discriminators in identifying the clumsy child. With the variables of crural index, physical appearance scale and general self scale the subject of secondary interest at this stage.

GROUPING THE CHILDREN

The cluster analysis based upon seventeen cases (subjects/children) produced clusters which can be seen following the step by step analysis of the clustering of cases. This step by step process in the cluster analysis is recorded also in Appendix 16. The clusters are determined by following the presentation of the results of the step by step procedure, in a similar fashion to that used for the variables. Of interest here, similar to the analysis of the variables, are three aspects associated with the analysis of the clustering of cases. They are: pairs of cases which join together early in the clustering process; individual cases remaining unattached until very late in the process; and, the clusters of cases into like groups, at a stage both statistically meaningful and also practically useful. In addition, the reasons why clusters would form in terms of similarities in the children's profiles is a necessary subordinate purpose for analysis in this section.

However, unlike the analysis of the variables, the characteristics of the children are explained less easily. In the previous analysis the measured parameters were much more familiar in terms of their similarity to other parameters, whereas, the children are less familiar being unknown to the researchers prior to the study. The difficulty in explaining differences in the children from simple descriptive comparisons, such as observational comparisons of individual profiles, may be due partly to the very high bivariate correlations between cases (see Appendix 12), which is much higher than between the variables. Therefore, the purpose of this section is as follows: to gain a complete understanding of the cluster analysis of the cases; provide for the stated subordinate purpose; and, facilitate the exploratory nature of the study. In attempting this, it is essential to explain more fully each step in the process in terms of the children's profiles.

STEP BY STEP ANALYSIS

Identification of interesting trends which occur at each of the steps in the cluster analysis, which is based on the children's characteristics, will facilitate the understanding of the groupings which emerge. The children's individual profiles (see Appendix 13) and the inter-correlation matrix for subjects (see Appendix 12), form the basis for comparison. It should be noted here that the cluster analysis technique does not group together necessarily those with the highest correlations, as the algorithm optimises the ratio of intra to inter cluster distances. However, inter-correlation coefficients may help to explain and reinforce similarities between subjects grouped together earlier in the clustering process. The grouping of cases at each step in the cluster analysis can be seen in Appendix 16 and a brief description of interesting trends at each step in the process follows.

Step One

Jack and Graham are the first cases to group, with a correlation coefficient of .993. This is the highest correlation between any two children (see Appendix 12). The comparison in percentile ranks on measures, in order of homogeneity can be seen in Table 5.5. They have thirteen measures of the seventeen used, which are within the same 25 percentile ranking range. Of those, twelve are within a percentile ranking range of fifteen, with eight within a range of ten.

Table 5.5 : A Description of Step One in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Difference in PRR
Brachial index	Identical	0
Crural Index	18 & 15	3
Abdominal Strength	32 & 38	6
Stamina	39 & 46	7
Relative Sitting Height	9 & 1	8
Arm Strength	21 & 13	8
Physical Appearance	11 & 20	9
Skinfold	20 & 10	10
Leg Power	14 & 3	11
NDI	80 & 68	12
Physical Ability	45 & 33	12
Flexibility	60 & 45	15
Peer Relations	33 & 9	24
Speed	60 & 30	30
Weight	87 & 45	42
Height	55 & 10	45
General Self	65 & 16	49

Both Jack and Graham have some biomechanical disproportionality of the limbs and a low relative sitting height. They have a weak musculature, high levels of body fat and exhibit similar attitudes towards themselves on two of the self-concept scales. At this stage in the analysis the most important observation is, that this pairing occurred as a consequence of these two children being more alike than the other children.

Step Two

Ivan and Cloe are the second cases to group, with a correlation coefficient of .977 (see Appendix 12). The comparison in percentile ranks on measures, in order of homogeneity can be seen in Table 5.6. They have twelve measures of the seventeen used, within the same 25 percentile ranking (PR) range. Of those, ten are within a percentile ranking range of fifteen, with seven within a range of ten. These two children, as well as being correlated closely, have similar individual profiles.

Table 5.6 : A Description of Step Two in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Difference in PRR
Weight	Identical	0
Brachial index	identical	0
Crural Index	2 & 3	1
NDI	72 & 74	2
Peer Relations	68 & 72	4
Stamina	35 & 40	5
Skinfold	5 & 15	10
Physical Ability	17 & 5	12
Physical Appearance	42 & 28	14
Height	80 & 95	15
Speed	30 & 7	23
Arm Strength	33 & 8	25
Abdominal Strength	32 & 60	28
Relative Sitting Height	70 & 100	30
Flexibility	65 & 35	30
Leg Power	35 & 90	55
General Self	96 & 16	80

They both have some biomechanical disproportionality of the limbs and identical weight. They are both very tall, have an almost identical NDI score, high levels of body fat and exhibit similar attitudes towards themselves on three of the self-concept scales. This pairing suggests that Ivan and Cloe are the second most alike pair of children in the group.

Step Three

Dennis and Brian are the third cases to group, with a correlation coefficient of .957 (see Appendix 12). The comparison in percentile ranks on measures, in order of homogeneity can be seen in Table 5.7. They have nine measures of the seventeen used, which are within the same 25 percentile ranking range. Of those, eight are within a percentile ranking range of fifteen, with seven within a range of ten.

Table 5.7 : A Description of Step Three in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Difference in PRR
Weight	identical	0
Brachial index	identical	0
Crural Index	1 & 5	4
Flexibility	85 & 80	5
Physical Appearance	95 & 86	9
Leg Power	14 & 5	9
Skinfold	20 & 10	10
Height	70 & 85	15
General Self	80 & 96	16
Physical Ability	87 & 57	30
Peer Relations	79 & 49	30
Abdominal Strength	10 & 40	30
Relative Sitting Height	18 & 50	32
Speed	0 & 33	33
NDI	90 & 64	36
Arm Strength	7 & 62	55
Stamina	30 & 86	56

The two boys have some biomechanical disproportionality of the limbs and identical weight. They have very similar flexibility and leg power scores, high levels of body fat and they exhibit similar attitudes towards themselves on two of the self-concept scales. This pairing forms the nucleus of the of the second largest group (n = 4) clustered at step twelve, where five clusters are established. The variables that remain most resilient, i.e., appear in the first ten at step three and at step twelve, are as follows: Brachial Index, Flexibility, General Self, Skinfold, Height and Physical Appearance (in order of ratings range at step twelve). This group is known as nucleus group (A) for identification purposes.

Step Four

Bruce and Robert are the fourth cases to group, with a correlation coefficient of .984 (see Appendix 12). Table 5.8. shows the comparison in percentile ranks on measures, in order of homogeneity. They have eleven measures of the seventeen used, which are within the same 25 percentile ranking range. Of those eight are within a percentile ranking range of fifteen, with six within a range of ten.

Table 5.8 : A Description of Step Four in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Difference in PRR
NDI	64 & 66	2
Speed	19 & 15	4
Skinfold	10 & 5	5
Flexibility	90 & 97	7
Physical Appearance	66 & 73	7
Height	50 & 60	10
Brachial index	42 & 28	14
Arm Strength	25 & 11	14
Crural Index	20 & 2	18
Stamina	39 & 18	21
Physical Ability	21 & 45	24
Peer Relations	55 & 25	30
Leg Power	40 & 2	38
Abdominal Strength	14 & 52	38
Relative Sitting Height	78 & 35	43
Weight	28 & 72	44
General Self	25 & 96	71

Bruce and Robert have an almost identical NDI score and very similar speed ratings. They have very high flexibility scores, high levels of body fat and exhibit similar attitudes towards themselves on the Physical Appearance scale. The pair are of medium height with similar proportions and strength rating in the upper limb.

This pairing forms the nucleus of the largest group (n = 9) clustered at step twelve, where five clusters are established. The variables that remain the most resilient, i.e., appear in the first ten at step three and at step twelve, are as follows: NDI, Crural Index, Skinfold, Flexibility, Arm Strength, Stamina and Speed (in order of ratings range at step twelve). This group is known as nucleus group (B) for identification purposes.

Step Five

At the fifth step in the clustering procedure, Darcy joins Bruce and Robert who paired up at the fourth step forming nucleus group (B). Darcy and Bruce have a correlation coefficient of .948, with Darcy and Robert correlating at .943 (see Appendix 12). The comparison in percentile ranks on measures for these three cases, in order of the range across the ranks, can be seen in Table 5.9[5.2]. Bruce and Robert have an almost identical NDI score and Darcy was associated with them because his NDI is very similar.

Table 5.9 : A Description of Step Five in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Range Across PRR
NDI	**68**, 64 & 66	4
Skinfold	**5**, 10 & 5	5
Speed	**12**, 19 & 15	7
Height	**50**, 50 & 60	10
Crural Index	**1**, 20 & 2	19
Arm Strength	**3**, 25 & 11	22
Flexibility	**65**, 90 & 97	32
Peer Relations	**21**, 55 & 25	34
Leg Power	**36**, 40 & 2	38
Stamina	**0**, 39 & 18	39
Brachial index	**1**, 42 & 28	41
Physical Ability	**2**, 21 & 45	43
Abdominal Strength	**4**, 14 & 52	48
Physical Appearance	**14**, 66 & 73	59
Weight	**100**, 28 & 72	72
Relative Sitting Height	**1**, 78 & 35	77
General Self	**16**, 25 & 96	80

All three have high levels of body fat and score similarly on Speed rating. The trio are all of medium height. The first six ordered variables in Table 5.9 remain within a range spanning 25 percentile rankings and appeared also in the first ten ranked variables at step four, where the group began. Of these six variables, four are within a ten range magnitude, they are: NDI, Skinfold, Speed and Height.

5.2 Rankings in **bold-type** indicate the newest cases to join the cluster, throughout this and subsequent tables.

Step Six

At the sixth step in the clustering procedure, Rachel joins Ivan and Cloe who paired up at the second step. Rachel and Cloe have a correlation coefficient of .974, with Ivan and Rachel correlating at .971 (see Appendix 12 . The comparison in percentile ranks on measures for these three cases, in order of the range across the ranks, can be seen in Table 5.10. This group remained intact until step twelve.

Table 5.10 : A Description of Step Six in the Cluster Analysis for Cases

Variable	**Respective Percentile Rank Ratings - PRR**	**Range Across PRR**
Brachial index	identical	0
Crural Index	**1**, 2 & 3	2
NDI	**68**, 72 & 74	6
Height	**87**, 80 & 95	8
Physical Ability	**20**, 17 & 5	15
Physical Appearance	**25**, 42 & 28	17
Weight	**82**, 100 & 100	18
Stamina	**54**, 35 & 40	19
Skinfold	**35**, 5 & 15	20
Relative Sitting Height	**100**, 70 & 100	30
Peer Relations	**31**, 68 & 72	41
Abdominal Strength	**75**, 32 & 60	43
Flexibility	**80**, 65 & 35	45
Arm Strength	**57**, 33 & 8	49
Leg Power	**65**, 35 & 90	55
Speed	**70**, 30 & 7	63
General Self	**37**, 96 & 16	80

Ivan and Cloe have Brachial and Crural Indices which were matched highly and Darcy was associated with them because his are very similar. All three are very tall children and scored similarly on the NDI. The trio were alike in two self-concept ratings. The first nine ordered variables in Table 5.10 remain within a range spanning 25 percentile rankings and appeared also in the first ten ranked variables at step two, where the group began. Of these nine variables, four are within a ten range magnitude, they are : Brachial Index, Crural Index, NDI and Height.

Step Seven

At the seventh step in the clustering procedure, Ann joins nucleus group (B) (i.e., Darcy, Bruce and Robert who grouped at the fifth step). Ann and Bruce have a correlation coefficient of .961, with Ann and Robert correlating at .962, and Ann and Darcy at .981 (see Appendix 12). The comparison in percentile ranks on measures for these four cases, in order of the range across the ranks, can be seen in Table 5.11.

Table 5.11 : A Description of Step Seven in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Range Across PRR
NDI	**66**, 68, 64 & 66	4
Skinfold	**20**, 5, 10 & 5	15
Speed	**30**, 12, 19 & 15	18
Crural Index	**1**, 1, 20 & 2	19
Arm Strength	**8**, 3, 25 & 11	22
Flexibility	**80**, 65, 90 & 97	32
Peer Relations	**31**, 21, 55 & 25	34
Stamina	**28**, 0, 39 & 18	39
Brachial Index	**1**, 1, 42 & 28	41
Physical Ability	**37**, 2, 21 & 45	43
Abdominal Strength	**35**, 4, 14 & 52	48
Height	**100**, 50, 50 & 60	50
Leg Power	**60**, 36, 40 & 2	58
Physical Appearance	**19**, 14, 66 & 73	59
Weight	**92**, 100, 28 & 72	72
Relative Sitting Height	**50**, 1, 78 & 35	77
General Self	**10**, 16, 25 & 96	86

Ann was attracted to nucleus group (B) primarily by a strong similarity in NDI, Skinfold and Speed. These three variables remained ordered as the first three and within a percentile ranking range of twenty, with Crural Index and Arm Strength proving somewhat similar. However, this step sees height, as a factor in clustering the cases, lose its importance.

Step Eight

At the eighth step in the clustering procedure, Jack and Graham, who paired at the first step, join nucleus group (B) (i.e., Ann, Darcy, Bruce and Robert). Correlation coefficients between these subjects can be seen in Appendix 12. Comparison in percentile ranks, on measures for these six cases in order of the range across the ranks, can be seen in Table 5.12.

Table 5.12 : A Description of Step Eight in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Range Across PRR
Skinfold	**20, 10**, 20, 5, 10 & 5	15
NDI	**80, 68**, 66, 68, 64 & 66	16
Crural Index	**18, 15**, 1, 1, 20 & 2	19
Arm Strength	**21, 13,** 8, 3, 25 & 11	22
Brachial Index	**1, 1**, 1, 1, 42 & 28	42
Physical Ability	**45, 33,** 37, 2, 21 & 45	43
Peer Relations	**33, 9,** 31, 21, 55 & 25	46
Stamina	**39, 46,** 28, 0, 39 & 18	46
Speed	**60, 30**, 30, 12, 19 & 15	48
Abdominal Strength	**32, 38,** 35, 4, 14 & 52	48
Flexibility	**60, 45,** 80, 65, 90 & 97	52
Leg Power	**14, 3,** 60, 36, 40 & 2	58
Physical Appearance	**11, 20,** 19, 14, 66 & 73	62
Weight	**87, 45,** 92, 100, 28 & 72	72
Relative Sitting Height	**9, 1,** 50, 1, 78 & 35	77
General Self	**65, 16,** 10, 16, 25 & 96	86
Height	**55, 10,** 100, 50, 50 & 60	90

Jack and Graham were attracted to nucleus group (B) primarily by a strong similarity in Skinfold, NDI and Crural Index. These three variables remained within the first four ordered and within a percentile ranking range of twenty, with Arm Strength proving somewhat similar. However, this step sees Speed, as factor in clustering the cases, lose its importance.

Step Nine

At the ninth step in the clustering procedure, Ross joins nucleus group (A) (i.e., Dennis and Brian) which formed at the fourth step. Ross and Dennis have a correlation coefficient of .935, with Ross and Brian correlating at .988 (see Appendix 12). Comparison in percentile ranks on measures for these three cases, in order of the range across the ranks, can be seen in Table 5.13.

Table 5.13 : A Description of Step Nine in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Range Across PRR
Brachial index	1, 1 & 1	0
Flexibility	**80**, 85 & 80	5
Leg Power	**15**, 14 & 5	10
General Self	**94**, 80 & 96	16
Physical Ability	**57**, 87 & 57	30
Peer Relations	**74**, 79 & 49	30
Abdominal Strength	**10**, 10 & 40	30
Relative Sitting Height	**18**, 18 & 50	32
Speed	**7**, 0 & 33	33
Skinfold	**45**, 20 & 10	35
Height	**50**, 70 & 85	35
Physical Appearance	**59**, 95 & 86	36
NDI	**63**, 90 & 64	37
Arm Strength	**12**, 7 & 62	55
Weight	**45**, 100 & 100	55
Stamina	**34**, 30 & 86	56
Crural Index	**70**, 1 & 5	69

Ross was attracted to nucleus group (A) primarily by a strong similarity in Brachial Index, Flexibility, Leg Power and General Self. These four variables were the only variables to remain within a percentile ranking range of twenty. However, this step sees Weight, Crural Index, Physical Appearance, Skinfold and Height, as factors in clustering the cases, lose their importance.

Step Ten

Jill and Emma are the fifth cases to pair together, with a correlation coefficient of .962 (see Appendix 12). The comparison in percentile ranks on measures, in order of homogeneity can be seen in Table 5.14. They have eleven measures of the seventeen used, which are within the same 25 percentile ranking range. Of those, five are within a percentile ranking range of fifteen, with two within a range of ten

Table 5.14 : A Description of Step Ten in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Difference in PRR
Brachial Index	identical	0
Arm Strength	9 & 16	7
Stamina	30 & 41	11
Skinfold	5 & 20	15
Height	25 & 40	15
Weight	95 & 78	17
Leg Power	45 & 25	20
Physical Appearance	73 & 52	21
Relative Sitting Height	1 & 23	22
NDI	64 & 86	22
Flexibility	65 & 90	25
Peer Relations	59 & 27	32
Speed	80 & 45	35
General Self	31 & 66	35
Physical Ability	67 & 23	44
Abdominal Strength	23 & 70	47
Crural Index	1 & 50	49

This pairing forms the only other group (n = 4) clustered at step twelve, where five clusters are established, as the fourth and fifth clusters consist of individual cases. The variables that have clustered these two together, other than those which play a major role in nucleus groups (A) and (B), are as follows: Arm Strength, Stamina, Height and Weight (all within a ranking range of twenty).

Step Eleven

At the eleventh step in the clustering procedure, the subjects who grouped at step six join nucleus group (B). Amalgamated they are: Rachel, Ivan, Cloe, Jack, Graham, Ann, Darcy, Bruce and Robert. Correlation coefficients between these subjects can be seen in Appendix 12. Comparison in percentile ranks on measures for these nine cases, in order of the range across the ranks, can be seen in Table 5.15.

Table 5.15 : A Description of Step Eleven in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Range Across PRR
NDI	**68, 72, 74**, 80, 68, 66, 68, 64 & 66	16
Crural Index	**1, 2, 3,** 18, 15, 1, 1, 20 & 2	19
Skinfold	**35, 5, 15**, 20, 10, 20, 5, 10 & 5	30
Brachial Index	**1, 1, 1**, 1, 1, 1, 1, 42 & 28	42
Physical Ability	**20, 17, 5**, 45, 33, 37, 2, 21 & 45	43
Arm Strength	**57, 33, 8**, 21, 13, 8, 3, 25 & 11	54
Stamina	**54, 35, 40**, 39, 46, 28, 0, 39 & 18	54
Speed	**70, 30, 7,** 60, 30, 30, 12, 19 & 15	58
Peer Relations	**31, 68, 72**, 33, 9, 31, 21, 55 & 25	59
Flexibility	**80, 65, 35**, 60, 45, 80, 65, 90 & 97	52
Physical Appearance	**25, 42, 28**, 11, 20, 19, 14, 66 & 73	62
Abdominal Strength	**75, 32, 60**, 32, 38, 35, 4, 14 & 52	71
Weight	**82, 100, 100**, 87, 45, 92, 100, 28 & 72	72
General Self	**37, 96, 16**, 65, 16, 10, 16, 25 & 96	86
Leg Power	**65, 35, 90**, 14, 3, 60, 36, 40 & 2	88
Height	**87, 80, 95**, 55, 10, 100, 50, 50 & 60	90
Relative Sitting Height	**100, 70, 100**, 9, 1, 50, 1, 78 & 35	99

Rachel, Ivan, Cloe were attracted to nucleus group (B) primarily by a strong similarity in NDI and Crural Index. These two variables remained within the first two ordered and within a percentile ranking range of twenty. However, this step sees Skinfold, as a factor in clustering cases, lose its importance.

Step Twelve

At the twelfth step in the clustering procedure, Greta joins nucleus group (A) (i.e., Ross, Dennis and Brian) which formed at the ninth step. Greta and Ross have a correlation coefficient of .99, with Greta and Dennis correlating at .925, Greta and Brian at .973 (see Appendix 12). Comparison in percentile ranks on measures for these four cases, in order of the range across the ranks, can be seen in Table 5.16.

Table 5.16 : A Description of Step Twelve in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Range Across PRR
Brachial Index	**1**, 1, 1 & 1	0
Flexibility	**85**, 80, 85 & 80	5
General Self	**96,** 94, 80 & 96	16
Abdominal Strength	**25,** 10, 10 & 40	30
Speed	**6**, 7, 0 & 33	33
Skinfold	**20**, 45, 20 & 10	35
Height	**85**, 50, 70 & 85	35
Physical Appearance	**95**, 59, 95 & 86	36
NDI	**71**, 63, 90 & 64	37
Physical Ability	**96,** 57, 87 & 57	39
Relative Sitting Height	**58,** 18, 18 & 50	40
Leg Power	**50**, 15, 14 & 5	45
Peer Relations	**95,** 74, 79 & 49	46
Weight	**100**, 45, 100 & 100	55
Arm Strength	**5**, 12, 7 & 62	57
Stamina	**3**, 34, 30 & 86	83
Crural Index	**95**, 70, 1 & 5	94

Greta was attracted to nucleus group (A) primarily by a strong similarity in Brachial Index, Flexibility and General Self. These three variables were the only ones to remain within a percentile ranking range of twenty. However, this step sees Leg Power, as a factor in clustering the cases, lose its importance. The five cluster solution created at this step, as explained in a subsequent section of this chapter, was selected as the most appropriate for grouping the subjects. The clusters formed can be seen in Table 5.20.

Step Thirteen

At the thirteenth step in the clus ering procedure, nucleus group (A) and (B) are amalgamated. This brings together Greta, Ross, Dennis, Brian, Rachel, Ivan, Cloe, Jack, Graham, Ann, Darcy, Bruce and Robert. Correlation coefficients between these subjects can be seen in Appendix 12. Comparison in percentile ranks on measures for these thirteen cases, in order of the range across the ranks, can be seen in Table 5.17.

Table 5.17 : A Description of Step Thirteen in the Cluster Analysis for Cases

Variable	Respective Percentile Rank Ratings - PRR	Range Across PRR
NDI	**71, 63, 90, 64,** 68, 72, 74, 80, 68, 66, 68, 64, 66	26
Crural Index	**95, 70, 1, 5,** 1, 2, 3, 18, 15, 1, 1, 20, 2	94
Skinfold	**20, 45, 20, 10,** 35, 5, 15, 20, 10, 20, 5, 10, 5	40
Brachial Index	**1, 1, 1, 1,** 1, 1, 1, 1, 1, 1, 1, 42, 28	42
Physical Ability	**96, 57, 87, 57,** 20, 17, 5, 45, 33, 37, 2, 21, 45	94
Flexibility	**85, 80, 85, 80,** 80, 65, 35, 60, 45, 80, 65, 90, 97	62
Arm Strength	**5, 12, 7, 62,** 57, 33, 8, 21, 13, 8, 3, 25, 11	59
Stamina	**3, 34, 30, 86**, 54, 35, 40, 39, 46, 28, 0, 39, 18	54
Speed	**6, 7, 0, 33**, 70, 30, 7, 60, 30, 30, 12, 19, 15	70
Peer Relations	**95, 74, 79, 49,** 31, 68, 72, 33, 9, 31, 21, 55, 25	86
Physical Appearance	**95, 59, 95, 86,** 25, 42, 28, 11, 20,19, 14, 66, 73	84
Abdominal Strength	**25, 10, 10, 40,** 75, 32, 60, 32, 38, 35, 4, 14, 52	71
Weight	**100, 45, 100, 100**, 82, 100, 100, 87, 45, 92,100, 28, 72	72
General Self	**96, 94, 80, 96,** 37, 96, 16, 65, 16, 10, 16, 25, 96	86
Leg Power	**50, 15, 14, 56,** 5, 35, 90, 14, 3, 60, 36, 40, 2	88
Height	**85, 50, 70, 85,** 87, 80, 95, 55, 10, 100, 50, 50, 60	90
Relative Sitting Height	**58, 18, 18, 50,** 100, 70, 100, 9, 1, 50, 1, 78, 35	99

This point in the clustering process sees none of the variables display homogeneity across cases. This decline in useful information, further reinforces the practical reasons to drop back from here and use the five clusters, established at the previous step, as the means for sorting the subjects. Clusters formed at step thirteen can be seen in Table 5.18 and those at step twelve in Table 5.20.

The pattern established up to step thirteen saw two main groups emerge. The largest (n=9) of these being based on nucleus group (B), with cases migrating to the cluster, during the process, through affinity in Skinfold, NDI, Crural Index and Arm Strength scores. The final amalgamation was based upon the large similarity of NDI and Crural Index ratings. The second largest group (n=4) was based on nucleus group (A) with cases migrating to the cluster, during the process, through affinity in Brachial Index, Flexibility, General Self and Leg Power scores. The final amalgamation for this cluster being based upon similarity in the first three parameters.

THE CLUSTERING OF CHILDREN

In terms of analysing each step, amalgamation of groups or individuals into clusters becomes a factor of the statistical procedure, rather than any meaningful reason as the clustering process proceeds. Therefore, at a point which is determined as being practically useful (in this case step thirteen) the step by step process becomes somewhat redundant. However, identification of the clusters of children, rather than details of the step in the process, still enables a deeper understanding of the groupings of children. This sub-section describes the clusters established in the later stages of the analysis, to facilitate this understanding.

The last three steps see the remaining groups or individual variables joining the thirteen-strong group established at step thirteen (see Table 5.18). Jill and Emma, the fifth cases to pair together, join the large group at step fourteen. Connie joins at step fifteen, and Lance is the last to be assimilated, to form a single cluster at step sixteen. The clusters formed during steps fourteen and fifteen can be seen in Table 5.19.

Table 5.18 : Cluster of Subjects from Analysis at Step Thirteen[5.3]

4 CLUSTERS : Cluster 1	Cluster 2	Cluster 3	Cluster 4
Gm Ja Da Rb Bc	Ji	L	Co
A I Ra De Bn	E		
Rs Gt Cl			

Using the individual profiles in Appendix 13, trends in these remaining subjects' profiles show differences to the two main groups formed by step twelve. Jill and Emma retained their discrete pairing until this stage with differences to the large cluster, demonstrating important

5.3 The Key for the names of the children in tables 5.18, 5.19, 5.20 is as follows :

Jack - Ja	Dennis - De	Jill - Ji	Emma - E
Ross - Rs	Darcy - Da	Ann - A	Cloe - Cl
Graham - Gm	Ivan - I	Greta - Gt	Connie - Co
Lance - L	Robert - Rb	Rachel - Ra	
Bruce - Bc	Brian - Bn		

similarities to each other in height, weight and arm strength. They are similar in height-weight proportions, i.e., relatively shorter and heavier, rather than taller and heavier, with closeness in Arm Strength ratings. Connie remains the second most independent individual characteristically, due to very low ratings, at the extremes, in Leg Power and Arm Strength. Lance remains the last to join the single cluster due to the highest rating on Crural Index, the group being predominantly low on this variable, combined with a very low Relative Sitting Height and low Speed ratings.

Table 5.19 : Cluster of Subjects from Analysis at Step Fourteen and Fifteen

3 CLUSTERS : Cluster 1	Cluster 2	Cluster 3
Gm Ja Da Rb Bc A I Cl Ra De Bn Rs Gt Ji E Cl	L	Co

2 CLUSTERS : Cluster 1	Cluster 2
Gm Ja Da Rb Bc A I Ra De Bn Rs Gt Ji E Cl Co	L

Five was selected as the appropriate denominator for clusters of subjects, due to reasons of practicality which were stated previously, and the 'elbow' in the inter-cluster distance curve at step twelve (see Figure 5.2).

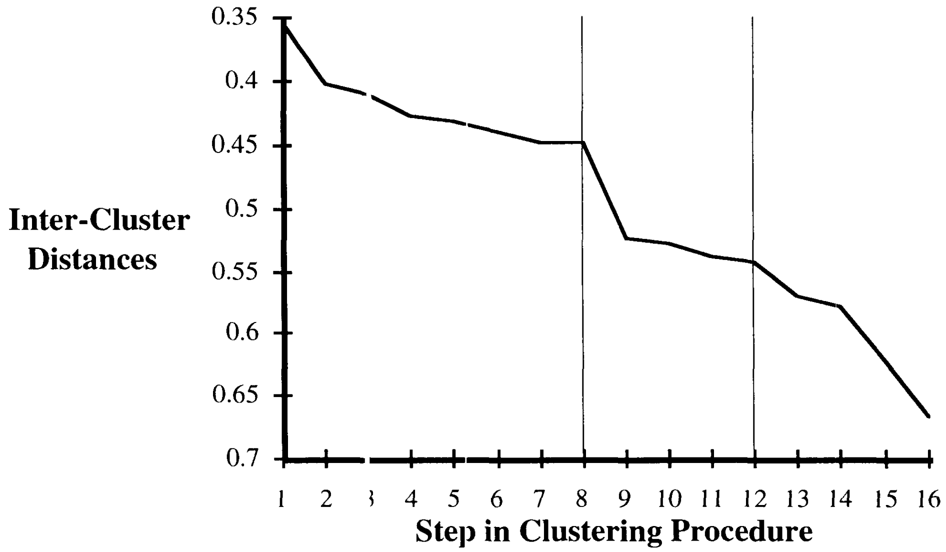

Figure 5.2 : Relative Distances Between Clusters at each Step in the Procedure (for clustering subjects)[5.4]

[5.4] The number of clusters formed at each step is established in reverse order to the numbering of steps themselves, i.e., one cluster at step 16, two clusters at step 15, etc.

The five clusters, which can be seen in Table 5.20, were formed on the basis of distinguishing features, in terms of the variables. A brief description of each cluster follows.

Table 5.20 : Cluster of Subjects from the Analysis at Step Twelve

5 CLUSTERS :		**Cluster 1**	**Cluster 2**		**Cluster 3**	**Cluster 4**	**Cluster 5**
Gm	Ja	Da	De	Bn	Ji	L	Co
Rb	Bc	A	Rs	Gt	E		
I	Ra	Cl					

Cluster 1

The subjects in Cluster 1 formed a more homogeneous group of nine as a consequence of likeness in NDI and Crural Index (percentile ranking range less than twenty). They were least alike in Relative Sitting Height, Height, Leg Power and General Self (percentile ranking range greater than 80). The NDI ranged from 64 to 80 and the Crural Index percentile rank from one to twenty. Children with a low Crural Index, moderate to mild disability ratings on NDI, and high levels of body fat, typified the characteristics of this group.

Cluster 2

The subjects in Cluster 2 formed a more homogeneous group of four as a consequence of likeness in Brachial Index, Flexibility and General Self (percentile ranking range less than twenty). They were least alike in Crural Index and Stamina (percentile ranking range greater than 80). Brachial Index remained at one for each group member. The Flexibility percentile rank ranged from 80 to 85, while the General Self percentile rank was from 80 to 96. Children with a low Brachial Index, high to very high flexibility ratings, high to very high ratings on the General Self scale, and poor abdominal strength and/or speed scores, typified the characteristics of this group.

Cluster 3

The subjects in Cluster 3 formed a more homogeneous group of two, as a consequence of likeness in Brachial Index, Arm Strength, Stamina, Skinfold, Height and Weight (percentile ranking range less than twenty). Although, as would be expected from a paired group, they remained more similar to each other on the remaining variables than did the two larger groups and they were also least alike in Crural Index and Abdominal Strength (percentile ranking range greater than 45). A comparison of their profiles (see Appendix 13) reveals much similarity in both dimensions mentioned above and the shape of their graphed profile, in terms of the seventeen variables analysed. However, only physical capacity parameters played a major role in determining their affinity in the clustering process, as all the stated likenesses were derived from this area of assessment and these constituted 50 per cent of the physical capacities measured.

Clusters 4 and 5

The subject in cluster five stayed independent of the others, as a consequence of ratings in Leg Power (one) and Arm Strength (nine) being distinctive in relation to others in the study group. The subject in cluster four stayed independent of the others, because of ratings in Crural Index (100), Relative Sitting Height (eight) and Speed (eight) being the distinctive features. However, it may be inconsequential to speculate on the importance of one case clusters in such a sample, as they could be another aberration of the statistical algorithm, rather than an aberration associated characteristically with clumsy children.

DISCUSSION

From the clustering of variables, Flexibility and Brachial Index were the first to pair together and NDI remained unattached until the final step. Flexibility and Brachial Index formed the basis of a cluster, which at the three cluster solution became a grouping containing only physical capacity variables. The significance of these two trends can be viewed in light of the results presented in Chapter 3. This means, these three measures were prominent in describing the study group and appear to be useful distinguishing features when identifying clumsy children.

A similar trend was seen in the second pair of variables to affiliate, i.e., Physical Appearance and General Self formed the basis of a cluster. This became the group containing only self-concept parameters, remaining clustered separately until the two cluster solution. The second last individual variable to be grouped was Abdominal Strength, remaining the second most robust, being absorbed at the four cluster solution. The significance of these trends is less noteworthy than those for NDI, Flexibility and Brachial Index, as they were second order factors in the cluster analysis. Moreover, they did not show the same prominence in the descriptive analysis of the study group, contained in Chapter 3. However, the General Self variable did play an important role in establishing a cluster formed of subjects in the second cluster analysis procedure.

The four cluster solution was selected as the most appropriate for describing the groups of variables, both in a practical and statistical sense. This solution provides confirmation that NDI is an important individual indicator and that the self-concept parameters are, as would be expected, closely aligned. In using the four cluster solution, rather than the observation of trends during steps of the analysis, Crural Index and Skinfold become a paired set of variables which are the last to join the physical capacities group, i.e., still resisting affiliation at the four cluster solution. The importance of this pairing and the resistance to join other like variables until late in the process is supported by these variables' prominence in grouping subjects, in that they became clear determinants in sorting cases into some of the clusters. Therefore, in addressing the question:

(B) How do the identified features group together in terms of the capacities and competencies of clumsy children?

it would seem that closely aligned physical capacities readily group together, with some exceptions, i.e., indicators of physical performance (e.g., Speed, Stamina) grouped together with most anthropometric measures. with the exceptions of Skinfold and Crural Index. Whereas, all of the measures of self-concept had grouped together at the selected juncture of the cluster analysis. However, the identifiable feature which proved common to all of the study group, NDI, was the most independent of all features included in the cluster analysis.

The five cluster solution was selected as the most appropriate for describing the groups of subjects, in a practical and statistical sense. The subjects in the largest cluster formed a group of nine as a result of affinity formed by NDI and Crural Index. These two parameters became the catalysts for the group. They were least alike in Relative Sitting Height, Height, Leg Power and General Self measures. The subjects in the next cluster formed a group of four as a result of affinity formed by Brachial Index, Flexibility and General Self. They were least alike in the Crural Index and Stamina variables. An interesting feature in distinguishing between these two largest clusters, is that they have an inverse relationship across two variables. This implies that Crural Index characterises the first group but tends to dissemble the second, with General Self delineating in an opposite manner.

The subjects in the next cluster formed a pair as a consequence of likeness in Brachial Index, Arm Strength, Stamina, Skinfold, Height and Weight. They were least alike in Crural Index and Abdominal Strength. Expectedly in a pair, they remained more similar to each other on the remaining variables than did the two larger groups. Subjects in the other two clusters stayed independent, forming clusters on their own. Ratings in Leg Power, Arm Strength, Crural Index, Relative Sitting Height and Speed being the relatively distinctive measures. However, clusters of this size do not possess notable qualities in their distinguishing features but rather in their differences to the larger groups. These differences, due to minimal dimensions, serve only to explain the reasons for not clustering with the others but not to identifying types of clumsy children Therefore, the trends here are less important for the study than those evident in the two larger clusters.

As mentioned previously, it would be expected that variables measuring similar dimensions would cluster together. The results of the first cluster analysis has achieved this by grouping like parameters together. However, coupled with evidence from the clustering of cases and the descriptive analysis contained in Chapter 3, the significance of the variables as possible discriminators of clumsy children becomes much stronger. In highlighting parameters only if they appear consistent with, and can be explained by, the other methods of description and analysis used in the study, important variables can be identified. Clearly, Flexibility, Brachial Index and NDI emerge as strong distinguishing features in recognising the clumsy child. With the variables of Crural Index, Skinfold rating and General Self scale as possible distinguishing features. In grouping clumsy children into possible sub-types, the cluster analysis has used the measured variables to group children in this study into three categories:

1) The largest cluster was established, by a grouping on homogeneity based primarily upon NDI and Crural Index with some secondary importance given to Skinfold rating.
2) A second grouping primarily based upon Brachial Index, Flexibility and General Self, emerged.
3) A category of aberrant cases or individuals/pairs showing strong independence from those more homogeneous groups, was evident.

Thereby, research question (C):

(C) Do clumsy children group together in more discrete sub-types based upon these identifiable features?
- If so, what are the characteristics of these groupings and/or which features show prominence in formulating the groups?

can be answered in the affirmative. In addition, identification of possible characteristics of the groupings and their relative prominence has been made.

Summary

As a result of the findings of this chapter, some features have been confirmed about the characteristics of the clumsy child, which arose in Chapter 3. Although Chapter 4 revealed a lack of transfer across tasks in individual children, it would seem, for sub-groups at least, there is some commonality in features which may distinguish clumsiness. In identifying these features, group analysis has been the common element of this and the two previous chapters. Important aspects pertaining to the research questions have been addressed and various facets of clumsiness and the grouping of clumsy children have emerged. However, group analysis cannot provide the depth of inquiry required in the study of human behaviour, as it is often the exception or the exaggerated features of an individual which proves the general rule. Chapter 6 provides that in-depth analysis through three case profiles of selected children involved in the study.