



ISSN: 2456-0057

IJPNPE 2017; 2(2): 741-744

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Received: 09-05-2017

Accepted: 10-06-2017

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Profiling physical fitness attributes in college students: A cluster analysis

Peter D Hart**Abstract**

Background: Health-related fitness traits vary greatly in general populations, ranging from very low to very high levels. However, less is known regarding fitness trait clustering,

Purpose: The purpose of this study was to determine if health-related fitness traits cluster in a college student population.

Methods: Data for this research came from a larger fitness measurement study and included N=131 college students attending a rural public university. Ten (10) fitness variables were used in this study. The first set of five variables represented each component of fitness and were used to construct the latent clusters. The second set of five variables were used to validate the identified clusters. All variables were T-score transformed before analysis. Cluster analysis was performed using the k-means method.

Results: Four clusters of individuals were identified in the analysis: 1) Anaerobic and Fit, 2) Aerobic and Fit, 3) Overweight and Unfit, and 4) Normal weight and Unfit. The original set of fitness variables all had significantly different ($p < .001$) means across the four cluster groups. The validation tests also showed all five variables with significantly different ($p < .05$) means across clusters.

Conclusion: Results from this study show that health-related fitness attributes in college students form four specific clusters. These findings may have implications for health promotion marketing of physical activity programs to college students.

Keywords: Cluster analysis, K-means, health-related fitness, college health

Introduction

The assessment of physical fitness is important because it can provide baseline standards for prescribing a new physical activity program as well as furnish data to gauge those program improvements [1]. There are two main categories of physical fitness: 1) skill-based physical fitness and 2) health-related physical fitness [2]. The latter receives more attention because of its associations with health outcomes [3, 4]. There are five defined components of health-related physical fitness [2]. These include cardiorespiratory fitness, muscular strength, muscular endurance, flexibility, and body composition. In college populations, only approximately half of students engage in moderate-intensity physical activity for at least 30 minutes on 5 or more days/week or vigorous-intensity physical activity for at least 20 minutes on 3 or more days/week [5, 6].

Given this, the assessment of health-related physical fitness in college student populations could serve as a viable health promotion intervention strategy in the marketing of physical activity [7]. Successful health promotion marketing strategies also incorporate business techniques such as market segmentation [8]. Therefore, a better understanding of the various subgroups of college students, in terms of health-related fitness, could aid in the application of market segmentation methods.

Cluster analysis is a class of statistical techniques that can group participants into homogenous sets based on specified variables [9, 10]. A good cluster analysis outcome would then show participants similar to each other in their assigned cluster and also show that they differ from those in other clusters. There is currently no published empirical evidence showing that fitness traits cluster in college students. The aim of this study was threefold: 1) to determine if fitness traits in college students cluster, 2) to name such clusters if they do exist, and 3) to validate these named clusters by showing how they differ across the same fitness traits from different fitness tests.

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Methods

Participants and design

Participants for this study were college students enrolled at a rural public university. Participants were recruited by word-of-mouth and campus flyers. Informed consent forms explained that participation was voluntary and included several health-related fitness tests to be performed at moderate to maximal levels and could be performed within a three-day period. To be eligible, participants had to fill-out a PAR-Q and indicate that they were generally healthy enough to engage in physical activity. All study methods and protocols were reviewed and approved by the university institutional review board (IRB).

Health-related fitness assessment

Two tests for each component of fitness were used for this study. The components are cardiorespiratory (CR), muscular strength (MS), muscular endurance (ME), flexibility (FL), and body composition (BC). CR tests included multi-stage fitness (Beep) test ^[11] and Queens College step (Step) test ^[12]. MS tests included 1RM leg press (1LP) test ^[13] and vertical jump (VJ) test ^[14]. The two ME tests were YMCA bench press (YMCABP) test ^[14] and flexed arm hang (FAH) test ^[15]. FL tests included sit-and-reach (SnR) test ^[13] and trunk lift (TL) test ^[15]. Finally, the BC tests included handheld bioelectrical impedance-determined percent body fat (HH) test ^[16] and waist circumference (WC) test ^[13]. The former test indicates an original cluster development test and the latter indicates a validation test.

Statistical Analysis

Cluster analysis was employed in this study using the k-means method. Optimal number of clusters was determined using the pseudo F (PSF) statistic. A relatively large value of PSF indicates an optimal number of clusters ^[17]. After clusters were formed, analysis of variance (ANOVA) was used to ensure that each fitness variable had significant mean differences across the identified cluster groups. After clusters were identified, a validation analysis was performed, which included ANOVA to ensure that each validation fitness variable saw the same mean differences across the identified cluster groups. Additionally, tests of linear trend were run to further test for incremental gain (or decline) in fitness variable trait across ranked cluster groups. Three different statistical software packages were used to ensure consistent cluster development by k-means method: SAS ^[18], SPSS ^[19], and R ^[20].

Results

Initial results found that four (4) latent clusters were optimal for describing the initial five fitness variable traits. This was indicated by a relatively large PSF statistic corresponding to four clusters, larger than any other k number of clusters. Figure 1 displays the five fitness variable cluster centers across the four identified clusters. Each cluster shows fitness attributes that are different from the others. For example, cluster #1 (farthest to the left) had the largest relative scores on both MS and ME tests, as compared to the other clusters. Whereas cluster #3 had the largest relative BC scores and lowest relative CR scores.

Figure 2 helps confirm the validity of the four-cluster model. Figure 2a shows a cluster plot that displays the first two principal components on the x and y axes. This plot demonstrates moderate separation of the two-dimensional space by the four cluster areas. Approximately 70% of the

variance is explained by the two principal components. Figure 2b is consistent in confirming these clusters when considering the bivariate relationships between the five fitness tests. That is, the four different colored points take up at least a moderate amount of their own two-dimensional space.

Table 1 identifies the 4 clusters of individuals by their fitness-related names: Cluster #1 was defined as *Anaerobic and Fit* because of its relatively high MS, ME, and FL scores with relatively moderate CR and BC scores. Cluster #2 was defined as *Aerobic and Fit* because of its relatively large CR scores, relatively low BC scores, and relatively moderate MS, ME, and FL. Cluster #3 was defined as *Overweight and Unfit* because of its relatively high BC scores, relatively moderate MS scores, and relatively low CR, ME, and FL scores. Finally, cluster #4 was defined as *Normal weight and Unfit* because of its relatively low BC, FL, ME, MS, and CR scores. The four identified clusters were statistically confirmed as seen by the significant ($p < .001$) omnibus ANOVA tests. To further examine cluster level differences, tests of linear trend were performed across ranked clusters. All tests of linear trend were significant ($p < .001$).

Table 1 also displays the validation portion of the analysis, which followed the same ANOVA procedures as above. All omnibus tests showed significant ($p < .05$) mean differences across cluster groups. Similarly, all tests showed a significant ($p < .05$) linear trend across ranked cluster groups. Figure 3 displays a visual of the tests of linear trend across the ranked cluster groups.

Discussion

The purpose of this study was to identify, name, and validate latent clusters of health-related fitness traits that were assessed in college students. Results showed that four distinct clusters were present in the data and named: 1) Anaerobic and Fit, 2) Aerobic and Fit, 3) Overweight and Unfit, and 4) Normal weight and Unfit. These statistically derived clusters also made sense theoretically. For example, it could be expected that two main categories of students would exist on any college campus, a fit population and an unfit population. This is supported by the fact that only approximately half of U.S. college students meet recommendations for moderate and/or vigorous intensity physical activity ^[5, 21]. Furthermore, different modes of structured physical activity would likely consist of activities that are considered either anaerobic (shorter duration activities such as sprinting, weight lifting, high intensity interval training, etc.) or aerobic (longer duration activities such as jogging, swimming, walking, cycling, etc.) ^[22]. Given this, the first two clusters (Anaerobic and Fit & Aerobic and Fit) described in this research would appear to also have a theoretical foundation.

Additionally, population-based studies have shown a large prevalence of overweightness in U.S. populations, including the college-aged subgroups. For example, a study by the Centers for Disease Control and Prevention (CDC) reported that approximately 20% of adults 18 to 29 years of age self-reported a body mass index (BMI) that categorized them as obese in 2009 ^[23]. Another study, using examination BMI data from the National Health and Nutrition Examination Survey (NHANES), reported that among U.S. adults 18 to 24 years of age, approximately 22 and 24% were measured to be overweight and obese, respectively ^[24]. Therefore, it is likely that among the unfit students in our study, a substantial proportion would be overweight or obese. This also provides a theoretical basis for the last two clusters (Overweight and Unfit & Normal weight and Unfit) described in this research.

Results from this cluster analysis should be considered along with the limitations of the study. One limitation is the population from which the sample was drawn. This study was conducted on college students attending a relatively small and rural public university. Given this fact, the findings from this study may not necessarily generalize to larger universities where student demographics may provide more variation and hence more latent cluster levels. A second limitation

concerning this study was the use of field-based physical fitness tests. The use of field-based tests may have allowed for less precision in terms of fitness trait measurement. Although criterion-based tests (i.e., hydrostatic weighing, indirect calorimetry, etc.) may have provided more precision in terms of fitness trait measurement, they also would have used more time and had been less familiar to and less efficient for the participants.

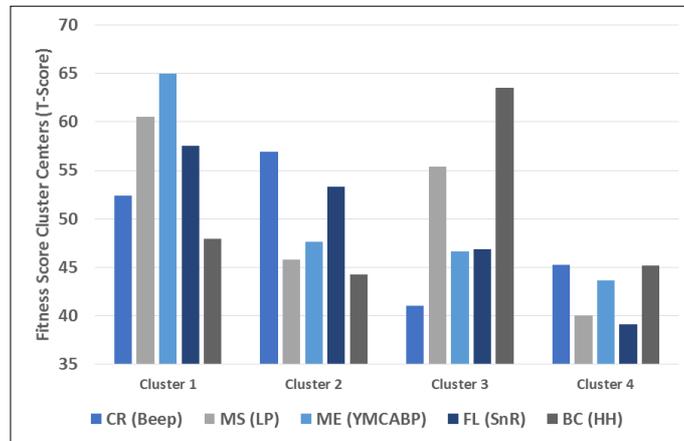


Fig 1: Relative Fitness Scores by Cluster and Fitness Component (N=131).

Note: Fitness test cluster centers were significantly ($p < .001$) different across clusters: CR ($F=33.9$), MS ($F=48.5$), ME ($F=53.5$), FL ($F=26.8$), and BC ($F=77.4$). Beep is the 40m beep test. LP is the 1RM leg press test. YMCABP bench press test. HH is PBF by handheld bioelectrical impedance method. SnR is the sit and reach test.

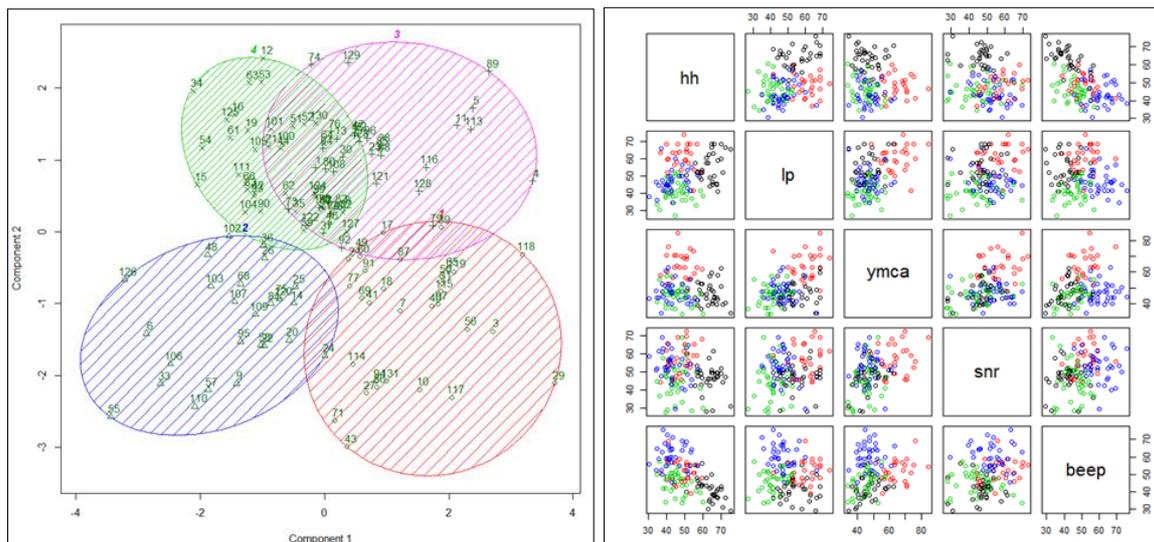


Fig 2: Cluster Plot (left) and Scatter Plot Matrix (right) each Showing Cluster Membership.

Note: The two components in 2a explain 70% of the point variance.

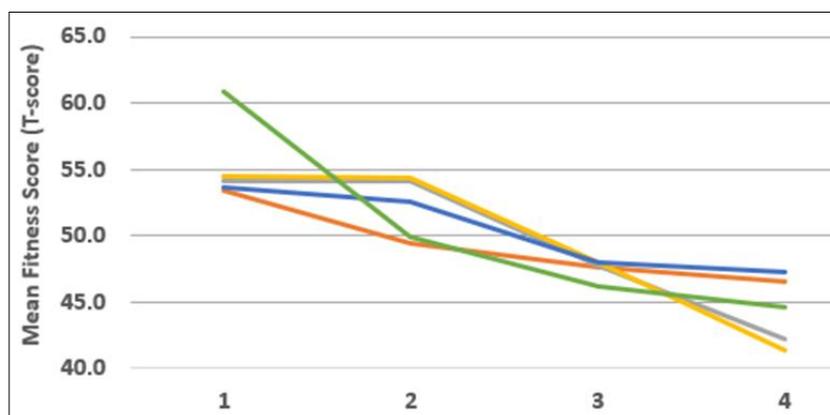


Fig 3: Trend Lines for Validation Fitness Tests Across Ranked Cluster.

Note: CR is orange. MS is gray. ME is yellow. FL is blue. BC is green.

Table 1: Fitness Score Means by Cluster Membership on Original and Validation Tests.

Fitness Test	Anaerobic/Fit (N=25)		Aerobic/Fit (N=50)		OW/Unfit (N=33)		NW/Unfit (N=23)		Omnibus p	Trend p
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Original										
CR (Beep)	52.4	5.9	56.9	9.1	41.0	6.3	45.2	6.5	<.001	<.001
MS (LP)	60.5	7.4	45.8	6.1	55.4	8.0	40.0	6.1	<.001	<.001
ME (YMCABP)	65.0	8.3	47.6	5.7	46.7	7.1	43.6	6.3	<.001	<.001
FL (SnR)	57.5	8.4	53.3	7.9	46.9	7.7	39.2	7.6	<.001	<.001
BC (HH)	48.0	5.8	44.3	6.0	63.6	5.6	45.2	6.7	<.001	<.001
Validation										
CR (Step)	49.5	8.6	53.4	8.4	47.7	11.5	46.6	10.6	.014	.003
MS (VJ)	54.2	7.8	54.1	8.9	42.2	8.8	47.7	8.7	<.001	<.001
ME (FAH)	54.3	9.0	54.5	9.3	41.4	5.9	47.9	8.5	<.001	<.001
FL (TL)	53.7	9.5	47.3	10.5	52.6	8.4	48.0	9.7	.014	.002
BC (WC)	50.0	6.2	44.6	5.6	60.9	10.9	46.2	6.7	<.001	.030

Note: Trend test was performed by first ranking each cluster membership by its respective fitness rank. All fitness measures were T-score transformed. OW is overweight. NW is normal weight. Beep is the 40m beep test. Step is the Queens College step test. LP is the 1RM leg press test. VJ is the vertical jump test. FAH is the flexed arm hang test. YMCABP is the YMCA bench press test. HH is PBF by handheld bioelectrical impedance method. WC is PBF by circumference method. SnR is sit and reach test. TL is the trunk lift test.

Conclusions

Results from this study show that fitness attributes in college students form four specific health-related fitness clusters: 1) Anaerobic and Fit, 2) Aerobic and Fit, 3) Overweight and Unfit, and 4) Normal weight and Unfit. These findings may have implications for health promotion intervention marketing of physical activity programs to college students. This research provides a better understanding of the different health-related market segments on college campuses.

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