RESEARCH ARTICLE

DOI: 10.34256/ijpefs2216

International Journal of
PHYSICAL EDUCATION, FITNESS AND SPORTS

Can Physical Fitness Performance be Used to Predict the BMI Status of First-Year Students? A Case Study from a University in Southern Taiwan

Chieh-Lun Hsieh [a], **Lorna A. Espeso** [a], **Cheng-Yen Sun** [b], **Yung-Hsiang Hu** [c,*]

[a] Ph.D. Educational Management Major in P.E., Graduate School, Emilio Aguinaldo College, Manila, 1007 Metro Manila, Philippines

[b] Department of Athletic Sports, College of Humanities and Social Sciences, Chang Jung Christian University, 71101 Tainan, Taiwan.

[c] General Education Center, College of Future, National Yunlin University of Science and Technology, 64002 Yunlin, Taiwan.

*Corresponding author Email: hsiang@yuntech.edu.tw

DOI: https://doi.org/10.34256/ijpefs2216

Received: 11-02-2022, Revised: 11-03-2022; Accepted: 11-03-2022; Published: 14-03-2022

Abstract: This study aims to investigate the relationship between the physical fitness performance of college freshmen and the BMI body weight status (normal/ abnormal). We conducted case studies and obtained data on 7,160 participants aged 18 years from a university in southern Taiwan. All participants completed four physical fitness tests (seated forward bench, standing long jump, sit-ups, and cardiorespiratory endurance) and BMI assessments with the professional assistance of PE teachers. BMI is used to define the normal and abnormal state of body weight. Logistic regression analysis was used in this study. The results show that the four physical fitness tests currently implemented in college physical education can be used to predict whether the weight of the freshmen is normal. Cardiorespiratory endurance seems to be the most important feature for predicting the type of BMI (normal/abnormal), whether male or female. When the "cardiorespiratory endurance" of freshman students increases by a category, the probability of males belonging to the healthy weight category increases by 4.879 times, and the probability of females increases by 2.927 times. This study provides a new perspective for predicting whether the freshman's body weight is normal or not by using different types of college physical fitness test performance.

Keywords: Physical fitness, BMI, Logistic regression, Cardiorespiratory endurance

About the Authors

Chieh-Lun Hsieh is a Ph.D. Student in Educational Management Major in P.E., Graduate School, Emilio Aguinaldo College, Manila, Philippines. The author is highly interested in research activities related to sports medicine in natural products and physical education.

Cheng-Yen Sun is working as an Assistant Professor and rugby coach in the Department of Athletic Sports, Chang Jung Christian University, Taiwan. The author's area of interest is a research activity in physical education in students' performance.

Lorna A. Espeso is a Principal, Senior High School, Adamson University; Professor of Graduate School, Emilio Aguinaldo College, Philippines. The author's area of interest is a research activity in physical education.

Yung-Hsiang Hu holds a degree in Ed.D and is currently employed as a full-time faculty of the General Education Center, College of Future, National Yunlin University of Science and Technology. His research focuses on e-Learning, Learning Analytics, innovational instruction, and institutional research.

1. Introduction

Physical education in higher education is to help students develop good exercise habits and improve their health and physical fitness. Many studies point out that physical activity is negatively related to many diseases, such as obesity, depression, coronary artery disease, cancer and diabetes [1-6]. Physical fitness has been regarded as one of the indicators that can predict health [7-8]. Observing physical fitness can also be used to indicate whether a person has developed exercise habits [9]. Today, physical fitness has aroused widespread concern and has been confirmed to be positively correlated with body weight [10]. Based on this good scientific evidence, not only the PE teachers are encouraged, but also a new window is opened for the application of physical fitness testing. In Taiwan, institutions at all levels have also followed the "National Physical Fitness Act" to measure students' physical fitness from the fourth grade of elementary school to the first grade of the university since 2000. This leads the university's PE teachers to focus on improving students' explosive power, muscular endurance, flexibility, and cardiorespiratory endurance, to improve students' physical fitness when designing teaching activities. Whether students can maintain good physical fitness and healthy weight has gradually become one of the indicators for teachers to self-review the effectiveness of teaching. However, recent studies have found that college students' physical activities significantly decreased [11]. In addition, the rapidly rising prevalence rate due to obesity has also been raised as a warning [12]. This means that PE teachers should effectively solve the continuous decrease in students' physical activity and pay attention to the deterioration of students' physical fitness and the constant increase in weight. Evidence shows that the degree of overweight is negatively correlated with the individual's physical fitness level [13-14]. When students are in poor physical fitness, their body composition may also have problems. Previous studies have explored how students' overweight or obesity affects their physical fitness performance, including reducing muscular endurance [15-17], cardiorespiratory endurance [18], flexibility [19], muscular strength/explosive power [10, 20-23]. However, to our knowledge, no studies have considered whether the physical fitness of college students can be used as a characteristic variable for predicting overweight. This may make it possible for students and physical education teachers to neglect the performance and application value of physical fitness. If PE teachers can predict whether students are overweight based on physical fitness, then teachers can make individualized physical activity plans based on it. In this way, teachers have a higher chance to guide students to increase their participation in sports activities. Today, the Body Mass Index (BMI) is a widely accepted and simple indicator for overweight. BMI has a significant relationship with physical fitness [24]. The present research provides a new perspective by using different types of physical fitness performance to predict BMI status (normal/ abnormal).

In this research, a binary logistic regression prediction model is created. The reason why the logistic regression method is chosen in this study is that many studies have pointed out that its effect is no less than other advanced machine learning method. [25-26] By using a dataset of observed physical fitness of a person based on their muscular endurance, cardiorespiratory endurance, flexibility, and muscular strength/explosive power, a prediction model is created to classify whether a college student is a normal or abnormal category. We conducted a case study to examine the university's physical fitness database and determine whether physical fitness can be used as a predictor of whether the BMI of college students is normal weight or not to provide information for more effective teaching and intervention measures in PE courses.

2. Materials and Methods

2.1. Data collection

The data in this study are collected from the physical fitness database of 7,160 students from a university in southern Taiwan during the 2017~2020 academic year. What we collect is the measurement data of students in their first grade. BMI was recorded six months after the physical fitness test was administered. Trained physical education teachers took all the measures.

The explanatory variables considered in this study included variables seated forward bench (flexibility), standing long jump (muscular strength), sit-ups (muscular endurance), and cardiorespiratory endurance. In this research, the dependent variable was BMI type, classified between normal (health weight) and abnormal (overweight and obese individuals). Due to the limited number of obese students, overweight and obese data were pooled for the analysis (n=568) in this research. BMI Type is expressed here as a binary variable with '0' meaning normal and '1' meaning abnormal. In terms of BMI type. In addition, cases of underweight, missing

values, null values, and values equal to zero are excluded from model training (n=509). In this research, the dataset (n= 6651, Male, 42.85% & Female, 57.15%) was divided into training composed of the 80% of subjects (n=5321), and testing composed of the remaining 20% of subjects (n=1330).

Previous studies have found that the relationship between BMI and physical fitness varies with gender and maturity level [27]. In this study, we divided the dataset into males and females. We use the BMI standard for children aged 18 years from the U.S Department of Health and Human Services [28]. The dataset used in this research consists of six columns which are as follows (Table 1):

2.2. Approach and Evaluation Criteria

In this study, we adopted the following approaches. First, the Standard Scaler was used in this research. Scaling was implemented to the four dependent variables (seated forward bend, standing long jump, sit-ups, and cardiorespiratory endurance). Then, to explore the relationship between health-related physical fitness levels and BMI type, each physical fitness measure was grouped into three by K-Means Clustering. Third, we used the chi-square test statistic to measure the significance of the association.

In this research, the logistic regression analyses for seated forward, bend standing long jump, sit-ups, and cardiorespiratory endurance was conducted to examine the odds of being overweight and healthy weight according to physical fitness in three categories. Binary Logistic Regression (LR) is the ratio between the probability of occurrence of an event and the probability of non-occurrence [29] which can be based on a binary dependent variable and several independent variables [30]. 95% confidence intervals (CI) and odds ratios (ORs) were calculated for each variable. However, collinearity can produce inappropriate results and reduce prediction accuracy [31].

Table 1. Dataset and the descriptions

Column	Information and Method
Gender	■ Participant's gender (i.e., Male, Female)
Seated Forward Bench (flexibility)	■ How many times can the participant do seat forward bench? -The subject sits on the ground or a mat with the legs apart and shoulders, knees straight, and toes facing upward. The subject's hands are folded (two middle fingers on top of each other), slowly stretch forward as far as possible, and after touching the cloth ruler with the middle finger, pause for two seconds. Two attempts can be made to collect better results for data analysis and recorded as centimeters.
Standing Long Jump (muscular strength, explosive power)	■ Performance measurement of participant's standing long jump. -Each subject was asked to stand at the starting line first and was asked to jump forward as far horizontally as possible. Both feet must jump up and land at the same time. The recorded distance was measured from the start mark of both feet to the nearest back of the foot. After two attempts, keep the maximum distance for analysis. Recorded as centimeters.
Sit-ups (muscular endurance)	■ How many times can the participant do the sit-ups. - Participants first lie on their backs on the mat, cross their hands in front of their chests, and bend their knees about ninety degrees. Others press their insteps with both hands to help stabilize. During the test, the subjects used the contraction of their abdominal muscles to make the upper body sit up, and the elbows touched the knees and then returned to the posture. In one minute, the performance is calculated by the number of times.
Cardiorespiratory Endurance	■ Measures of participant's cardiorespiratory endurance. - Participants complete the test by running (if they can't run, they can walk instead). Record the time when reaching the finish line (1600 meters for male and 800 meters for female). The test was measured in minutes and seconds.
BMI	■ Participant's BMI -Weight (kg)/Height^2 (m) -We adopted the definition from 2000 CDC growth charts—normal weight is defined as 18.5 ≤ BMI < 25 kg/m2, abnormal (including both overweight and obese individuals) as BMI ≥ 25 kg/m^2 [29].

Table 2. Basic characteristics of participants

Variables	Total N (%)	Male N (%)	Female N (%)	*P* value
Gender	5321 (100%)	2280 (42.9%)	3041 (57.1%)	—
BMI type				—
Normal(Healthy Weight)	4754 (89.3%)	1837 (83.5%)	2917 (93.4%)	
Abnormal (including both overweight & obese)	568 (10.7%)	362 (16.5%)	206 (6.6%)	
Seated Forward Bench				< .001***
Above	613 (11.5%)	338 (14.8%)	275 (9.0%)	
Average	1906 (35.8%)	906 (39.8%)	1000 (32.9%)	
Low	2802 (52.7%)	1035 (45.4%)	1767 (58.1%)	
Standing Long Jump				< .001***
Above	626 (11.8%)	343 (15.1%)	283 (9.3%)	
Average	1913 (35.9%)	912 (40.0%)	1001 (32.9%)	
Low	2782 (52.3%)	1024 (44.9%)	1758 (57.8%)	
Sit-ups				< .001***
Above	642 (12.1%)	352 (15.4%)	290 (9.5%)	
Average	1910 (35.9%)	913 (40.0%)	997 (32.8%)	
Low	2770 (52.0%)	1017 (44.6%)	1752 (57.7%)	
Cardiorespiratory Endurance				< .001***
Above	621 (11.7%)	347 (15.2%)	267 (8.8%)	
Average	1922 (36.1%)	923 (40.5%)	999 (32.9%)	
Low	2779 (52.2%)	1010 (44.3%)	1769 (58.3%)	

*p<.05, **p<.01, ***p<.001

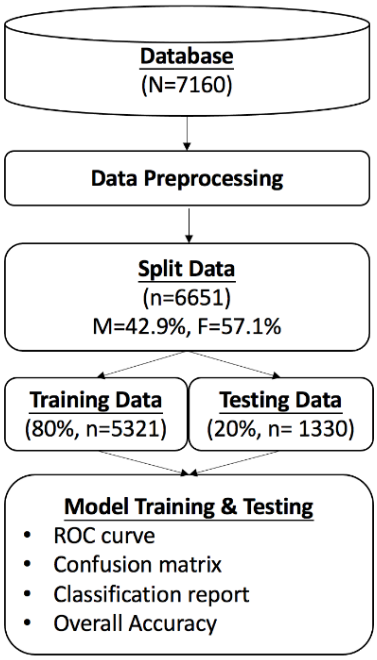


Figure 1. Flowchart of the Prediction Model Design

Therefore, in this study, multicollinearity is used to understand whether there is a correlation between the four independent variables. Specifically, we use equation (1) to obtain an estimated variance inflation factor (VIF) to detect multicollinearity, where R2 is the coefficient of determination for the regression of the explanatory variable on all other explanatory variables.

$$\mathrm{VIF} = \frac{1}{1 - R^2} \qquad (1)$$

Furthermore, the receiver operating characteristic curve (ROC) is a method that evaluates the accuracy of classification models like the logistic regression model. It offers visualization and scalability of the classification accuracy. The ROC curve is drawn by the relation between specificity and sensitivity [32]. On the ROC curve, the vertical axis is the true positive rate (TPR), and the horizontal axis is the false positive rate (FPR). The area between the x-axis and the ROC curve is called the "area under the curve (AUC)." In the study, AUC was used as a performance indicator of the classification accuracy of the logistic regression model. The confusion matrix is used as the statistical performance of the model in this study, which is generated based on the predicted value and observed events [33]. Figure. 1 shows the flow of the prediction

model of how the implementation will be carried out. And P-value < 0.05 were considered statistically significant.

The confusion matrix is composed of four indicators: true positive (TP), true negative (TN), false positive (FP), and false negative (FN). These evaluation indicators are used in this study to evaluate the performance of predictions. TP and TN represent the case where the actual result and the predicted result are the same, while FP and FN represent the case where the opposite result is obtained. In addition, Precision, Recall, F1-score, and Support are classified as reports in this study. The Precision indicator represents what percent of predictions are correct. Recall describes the percentage of positives that are correctly identified. The F1 score is the percentage of positive predictions that are correct. Support is the actual number of class occurrences in the specified data set.

Based on the confusion matric model, precision, accuracy, recall(sensitivity), and F1-Score are calculated using Eqs. (2), (3), (4), and (5) [34].

$$\text{precision} = \frac{\text{TP}}{\text{TP} + \text{FP}} \quad (2)$$

$$\text{accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}} \quad (3)$$

$$\text{recall(sensitivity)} = \frac{\text{TP}}{\text{TP} + \text{FN}} \quad (4)$$

$$\text{F1} - \text{Score} = 2\frac{\text{precision x recall}}{\text{precision x recall}} \quad (5)$$

The prediction model in this research was made using Python 3.9.6.

3. Results

3.1. Chi-square test and VIF

Table 2 shows the distribution and the result of the chi-square test relationship. The result shows that the seated forward bench (p< .001), standing long jump (p< .001), sit-ups (p< .001), and cardiorespiratory endurance (p< .001) play significant role in BMI type.

After determining the explanatory variables above, the next step is to filter them by performing multicollinearity analysis. This can be done by calculating the value of the VIF for each category. The value of VIF is greater than 10 indicates that the variable has a high degree of multicollinearity [35] and further analysis should not be considered [36]. According to Table 3, the results of the multicollinearity test show that there is no collinearity in this study. Therefore, these four variables were used in this study (Table 3).

Table 3. VIF value for each independent variable on male BMI prediction model

Explanatory variable	VIF value	
	Male	Female
Seated Forward Bend	2.288639	3.351330
Standing Long Jump	6.608700	2.378743
Sit-ups	5.682863	2.814725
Cardiorespiratory Endurance	2.945395	1.748947

Table 4. The regression coefficient of male/female BMI prediction model

Model	Explanatory variable	B	Std. Error	Wald	df	Sig	Exp(B)
Male	*Constant*	-5.432	.632	73.948	1	.000	.004
	Seated Forward Bend	.356	.133	7.223	1	.007	1.428
	Standing Long Jump	-.847	.175	23.502	1	.000	.429
	SitUps	-1.263	.167	57.102	1	.000	.283
	Cardiorespiratory Endurance	1.585	.102	243.176	1	.000	4.879
Female	*Constant*	-3.135	.521	36.149	1	.000	.044
	Seated Forward Bend	-.469	.240	3.807	1	.051	.626
	Standing Long Jump	-1.192	.321	13.766	1	.000	.304
	SitUps	-.617	.258	5.717	1	.017	.540
	Cardiorespiratory Endurance	1.704	.107	100.011	1	.000	2.927

*The reference category is overweight

Table 5. Result of logistic regression model on BMI odds ratio

Explanatory variable	Normal- Healthy Weight	
	Male	Female
Seated Forward Bend	1.428 (1.101 – 1.851)	.626 (.391 – 1.002)
Standing Long Jump	.429 (.304 – .604)	.304 (.162 – .570)
Sit-Ups	.283 (.204 – .392)	.540 (.325 – .895)
Cardiorespiratory Endurance	4.879 (3.998 – 5.955)	2.927 (2.372 – 3.613)

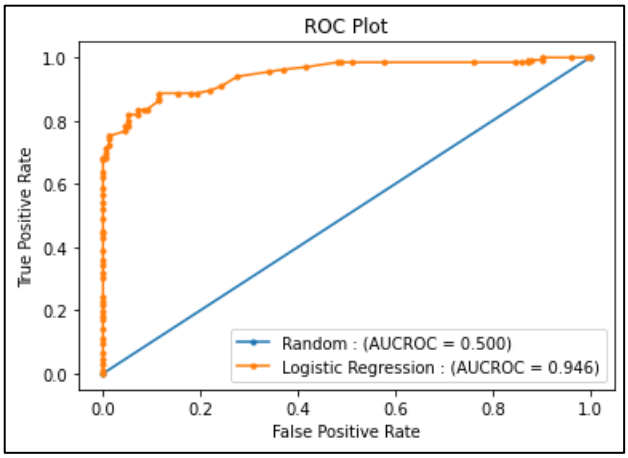


Figure 2. ROC curve for male model

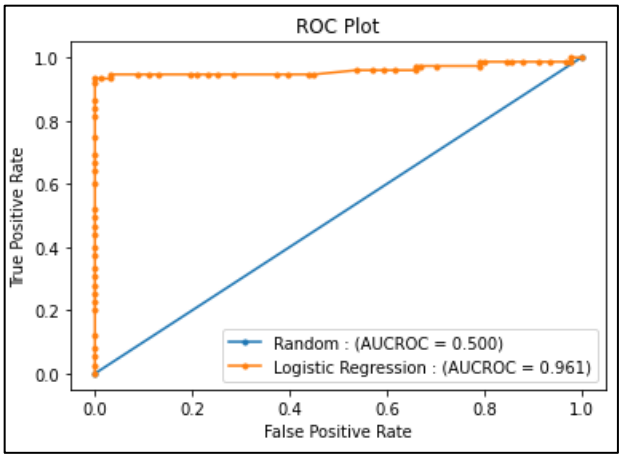


Figure 3. ROC curve for female model

Table 6. Confusion matrix for male BMI prediction model

Test Data / Amount given	Predicted as	
	Normal	Abnormal
Normal(healthy weight) / 308	286	22
Abnormal (including both overweight & obese) / 262	43	219

Table 7. Confusion matrix for female BMI prediction model

Test Data / Amount given	Predicted as	
	Normal	Abnormal
Normal (healthy weight) / 417	412	5
Abnormal (including both overweight & obese) / 343	23	320

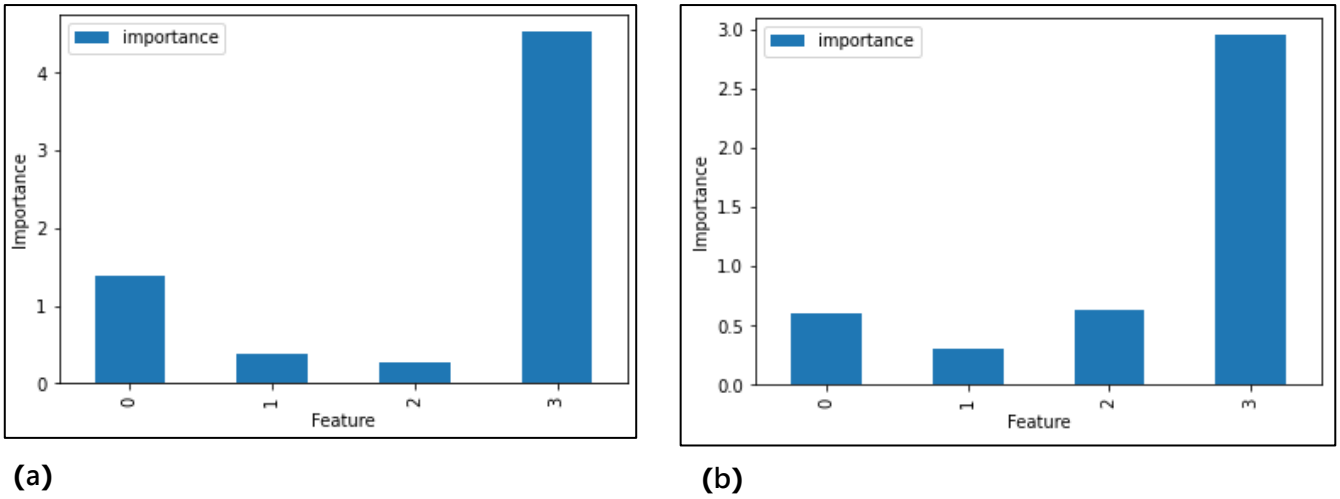
Table 8. Classification report

Model		Precision	Recall	F1-score	Support
Male	Normal (healthy weight)	.87	.93	.90	308
	Abnormal (including both overweight & obese)	.91	.83	.87	262
	Accuracy			.89	570
	Macro average	.89	.88	.88	570
	Weighted Average	.89	.89	.89	570
Female	Normal (healthy weight)	.95	.99	.97	417
	Abnormal (including both overweight & obese)	.99	.93	.96	343
	Accuracy			.96	760

	Macro average	.97	.96	.96	760
	Weighted Average	.96	.96	.96	760

Table 9. Accuracy and confidence value for two models

Model	BMI type	Confidence	Overall Accuracy
Male	Normal (healthy weight)	90%	89%
	Abnormal (including both overweight & obese)	87%	
Female	Normal (healthy weight)	97%	96%
	Abnormal (including both overweight & obese)	96%	



(a) (b)

a. left:(a)-Male; right:(b)-Female
b. 0: seated forward bend, 1: standing long jump, 2: sit-ups, 3: cardiorespiratory endurance

Figure 4. BMI type Prediction Feature Importance Bar.

3.2. Model Training

This research divides the dataset into 80% for training and 20% for testing. Regression coefficient for each factor used in making the logistic regression are as follows (Table 4).

In logistic regression models of BMI, for each one increasing category of 'seated forward bend', it has raised the odds of person belonging to healthy weight category by 1.428 times (95% confidence interval [CI], 1.101 – 1.851) for male, and .626 times (95% confidence interval [CI], .391 – 1.002) for female. For each one increasing category of 'standing long jump', it has raised the odds of person to belong to healthy weight category by .429 times (95% confidence interval [CI], .304 – .604) for male, and .304 times (95% confidence interval [CI], .162 – .570) for female. For each one increasing category of 'sit ups', it has raised the odds of person to belong to the healthy weight category by .283 times (95% confidence interval [CI], .204 – .392) for male, and .540 times (95% confidence interval [CI], .325 – .895) for female. For each one increasing category of 'cardiorespiratory endurance', it has raised the odds of a person belonging to the healthy weight category by 4.879 times (95% confidence interval [CI], 3.998 – 5.955) for male, and 2.927 times (95% confidence interval [CI], 2.372 – 3.613) for female. The results of the logistic regression models were shown in Table 5.

The performance of both the male and female models described by the Receiver Operator Characteristic (ROC) curve is below (Figure 2, 3). We confirm that the proposed method has excellent diagnostic power through the above ROC curve. In Figure 5, the area under the ROC curve (AUC) is .946. In Figure 6, the area under the ROC curve (AUC) is .961. Generally, the classification accuracy of the ROC curve can be divided into not good ($.6 < AUC \leq .7$), worthless ($.7 < AUC \leq .8$), good ($.8 < AUC \leq .9$), and excellent ($0.9 < AUC \leq 1$) [37]. Since fields greater than .9 were obtained, these indicate the excellent quality of the constructed model.

3.3. Model Testing

After the training data has been completed, testing is carried out to see accuracy. The record of the prediction results for the male gender obtained is as follows (Table 6). From 308 healthy weight data given, the model managed to predict it correctly 286 times. Of the 262 overweight data provided, the model predicted it correctly 219 times.

Prediction results for the female gender obtained are as Table 7. From the 417 healthy weight data given, the model managed to predict it correctly 412 times. Of the 343 abnormal data provided, the model predicted it precisely 320 times.

Based on the accuracy, recall, and specificity calculated above, the accuracy of each category and the total accuracy are described in Table 8 [34].

In Table 9, the overall accuracy of the Male (89%) and Female (96%) model reflects excellent results. The confidence (Healthy Weight: Male, 90% & Female, 97%; Overweight: Male, 87% & Female, 96%) reflect good result of two model.

Besides the model's overall accuracy, we also want to know which features are most important in predicting the output. It can be done by calculating the feature importance value. From the feature importance bar in Figure 4(a), we can conclude that cardiorespiratory endurance seems to be the most important feature in predicting BMI type (normal/abnormal) for the male BMI prediction model. Followed by seated forward bend, standing long jump, and then sit-ups. In Figure 4(b), we can conclude that cardiorespiratory endurance seems to be the most crucial feature in predicting BMI type (normal/abnormal) for the female BMI prediction model. Followed by seated forward bend, sit-ups, then standing long jump.

4. Discussion

This research investigates the associations between students' physical fitness and BMI weight. The study was conducted from a case university using freshmen's physical fitness test data. Based on the findings, associations were observed in all physical fitness performance and BMI measurements among both genders. According to the results of physical fitness level, whether it is cardiorespiratory endurance, standing long jump (muscle strength), sit-ups (muscular endurance) and seated forward bench (flexibility) performance may be good predictors of BMI. For example, if the "cardiorespiratory endurance" of freshman students increases by a category, the probability of males belonging to the healthy weight category increases by 4.879 times, and the probability of females increases by 2.927 times. Cardiorespiratory endurance is the most important feature in predicting BMI type (normal/ abnormal).

The results are comparable to existing findings. Different performance levels of muscle strength, endurance, and flexibility can effectively predict abdominal obesity in both Male and female [38]. People who regularly participate in physical activities show good cardiorespiratory endurance and muscle strength, endurance, and flexibility [39]. People who maintain a healthy weight are more likely to engage in physical activity [40]. Increasing exercise intensity is associated with a lower risk of weight gain [41].

The advantage of this research lies in directly analyzing the data of students' physical fitness tests and BMI in physical education classes. These are the data easily obtained by physical education teachers and students themselves. PE teachers can easily design sports activities by observing students' weaker physical fitness performance and providing students with appropriate sports training plans. However, some limitations should be resolved. First, this study only uses BMI to measure body weight. However, abdominal obesity (such as waist circumference or waist-to-hip ratio) was not used as a predictive result. Neither body weight nor abdominal obesity is the only indicators of health. Suppose physical education only seeks to make the student's BMI weight look normal while ignoring abdominal obesity or failing to develop continuous exercise habits. In that case, it will violate the purpose of physical education. Future research should consider including multiple indicators. Second, the sample in this study only covers one university and only predicts current weight status. The cross-institution and grade samples and factors other than gender have not been considered. Enlarging the analyzed sample is essential for the inference and application of research findings. In the future, consider a larger sample or cross-institution and age research, and include some background variables, such as diet history, living habits, etc.

Last but not least, this study only proposes that teachers can predict whether students' BMI is normal or abnormal based on their physical fitness. However, due to the limitation of the insufficient number of research samples, this study failed to fully

satisfy the classification of underweight, normal, overweight, and obesity. We suggest that future research be conducted through institutional research cooperation or expand the sample size to understand this issue more comprehensively.

5. Conclusion

According to the results of this study, the four physical fitness tests currently implemented in college physical education classes (seated forward bench, standing long jump, sit-ups, and cardiorespiratory endurance) can all be used to predict whether the bodyweight of new students is normal or abnormal. However, it has been observed that, whether male or female, cardiorespiratory endurance is the most important feature. Specifically, the different performance levels of flexibility, muscular strength, muscular endurance, and cardiorespiratory endurance effectively predict the BMI weight status of the two sexes. However, the mechanism by which physical fitness performance affects students' normal or abnormal BMI weight remains unclear. Still need to investigate further.

References

[1] M. Wanner, A. Richard, B. Martin, D. Faeh, S. Rohrmann, Associations between self-reported and objectively measured physical activity, sedentary behavior and overweight/obesity in NHANES 2003-2006, International Journal of Obesity, 41 (2017) 186-193. [DOI] [PubMed]

[2] E.M. McMahon, P. Corcoran, G. O'Regan, H. Keeley, M. Cannon, V. Carli, C. Wasserman, G. Hadlaczky, M. Sarchiapone, A. Apter, J. Balazs, M. Balint, J. Bobes, R. Brunner, D. Cozman, C. Haring, M. Iosue, M. Kaess, J.P. Kahn, B. Nemes, T. Podlogar, V. Poštuvan, P. Sáiz, M. Sisask, A. Tubiana, P. Värnik, C.W. Hoven, D. Wasserman, Physical activity in European adolescents and associations with anxiety, depression and well-being, European Child & Adolescent Psychiatry, 26 (2017) 111-122. [DOI] [PubMed]

[3] Y. Zeng, G. Wang, C. Xie, X. Hu, J. Reinhardt, Prevalence and correlates of depression, anxiety, and symptoms of stress in vocational college nursing students from Sichuan, China: a cross-sectional study, Psychology, Health & Medicine, (2019) 798-811. [DOI] [PubMed]

[4] D.R. Laddu, J.S. Rana, R. Murillo, M.E. Sorel, C.P. Quesenberry, N.B. Allen, K.P. Gabriel, M.R. Carnethon, K. Liu, J.P. Reis, D. Lloyd-Jones, J.J. Carr, S. Sidney, 25-Year Physical Activity Trajectories and Development of Subclinical Coronary Artery Disease as Measured by Coronary Artery Calcium: The Coronary Artery Risk Development in Young Adults (CARDIA) Study, Mayo Clinic Proceedings, 92 (2017) 1660-1670. [DOI] [PubMed]

[5] S.C. Moore, I.M. Lee, E. Weiderpass, P.T. Campbell, J.N. Sampson, C.M. Kitahara, S.K. Keadle, H. Arem, A.B.D. Gonzalez, P. Hartge, H.O. Adami, C.K. Blair, K.B. Borch, E. Boyd, D.P. Check, A. Fournier, N.D. Freedman, M. Gunter, M. Johannson, K.T. Khaw, M.S. Linet, N. Orsini, Y.K. Park, E. Riboli, K. Robien, C. Schairer, H. Sesso, M. Spriggs, R.V. Dusen, A. Wolk, C.E. Matthews, A.V. Patel, Association of Leisure-Time Physical Activity With Risk of 26 Types of Cancer in 1.44 Million Adults, JAMA Internal Medicine, 176 (2016) 816-825. [DOI] [PubMed]

[6] A. Kandola, D. Vancampfort, M. Herring, A. Rebar, M. Hallgren, J. Firth, B. Stubbs, Moving to beat anxiety: epidemiology and therapeutic issues with physical activity for anxiety, Current Psychiatry Reports, 20 (63) (2018) 0043270. [DOI] [PubMed]

[7] K. Silventoinen, J. Maia, A. Jelenkovic, S. Pereira, É. Gouveia, A. Antunes, M. Thomis, J. Lefevre, J. Kaprio, D. Freitas, Genetics of somatotype and physical fitness in children and adolescents, American Journal of Human Biology, (2020) e23470. [DOI] [PubMed]

[8] A. García-Hermoso, I. Cavero-Redondo, R. Ramírez-Vélez, J.R. Ruiz, F.B. Ortega, D.C. Lee, V. Martínez-Vizcaíno, Muscular Strength as a Predictor of All-Cause Mortality in an Apparently Healthy Population: A Systematic Review and Meta-Analysis of Data From Approximately 2 Million Men and Women, Archives of Physical Medicine and Rehabilitation, 99 (2018) 2100-2113.e5. [DOI] [PubMed]

[9] D.L. Swift, C.J. Lavie, N.M. Johannsen, R. Arena, C.P. Earnest, J.H. O'Keefe, R.V. Milani, S.N. Blair, T.S. Church, Physical activity, cardiorespiratory fitness, and exercise training in primary and secondary coronary prevention, Circulation Journal, 77 (2013) 281-292. [DOI] [PubMed]

[10] C. Ding, Y. Jiang, The Relationship between Body Mass Index and Physical Fitness among Chinese University Students: Results of a Longitudinal Study, Healthcare (Basel), 8(4) (2020) 570. [DOI] [PubMed]

[11] S.-P. Fagaras, L.-E. Radu, G. Vanvu, The level of physical activity of university students, Procedia - Social and Behavioral Sciences, (2015) 197, 1454–1457. [DOI]

[12] R.J.R. Levesque, The Encyclopedia of Adolescence (2nd Ed.). 2018, NewYork: Springer Publishers. pp. 2561-2565.

[13] G. Tomkinson, T. Olds, Secular changes in pediatric aerobic fitness test performance: The global picture, Medicine and Sport Science, 50 (2007) 46-66. [DOI] [PubMed]

[14] M.S. Tremblay, M. Shields, M. Laviolette, C.L. Craig, I. Janssen, S.C. Gorber, Fitness of Canadian children and youth: Results from the 2007–2009 Canadian Health Measures Survey, Health Report, 21 (2010) 7-20. [PubMed]

[15] M. Gäbler, O. Prieske, T. Hortobágyi, U. Granacher, The Effects of Concurrent Strength and Endurance Training on Physical Fitness and Athletic Performance in Youth: A Systematic Review and Meta-Analysis, Frontiers in Physiology, 9 (2018) 1057. [DOI] [PubMed]

[16] Y. Liao, S.H. Chang, M. Miyashita, D. Stensel, J.F. Chen, L.T. Wen, Y. Nakamura, Associations between health-related physical fitness and obesity in Taiwanese youth, Journal of Sports Sciences, 31 (2013) 1797-1804. [DOI] [PubMed]

[17] E.C. de Andrade Gonçalves, D. Augusto Santos Silva, H.E. Gimenes Nunes, Prevalence and Factors Associated With Low Aerobic Performance Levels in Adolescents: A Systematic Review, Current Pediatric Reviews, 11 (2015) 56-70. [DOI] [PubMed]

[18] R. Peng, S. Li, H. Zhang, H. Zeng, B. Jiang, Y. Liu, X. Yi, M. Xu, L. Zhu, Z. Zhang, Weight Status Is Associated with Blood Pressure, Vital Capacity, Dental Decay, and Visual Acuity among School-Age Children in Chengdu, China, Annals of Nutrition and Metabolism, 69 (2016) 237–245. [DOI] [PubMed]

[19] J.W. Kim, D.I. Seo, B. Swearingin, W.Y. So, Association between obesity and various parameters of physical fitness in Korean students, Obesity Research & Clinical Practice, 7 (2013) e67-e74. [DOI] [PubMed]

[20] V.P. Lopes, M. Cossio-Bolaños, R. Gómez-Campos, M. de Arruda, J.E. Hespanhol, L.P. Rodrigues, Linear and nonlinear relationships between body mass index and physical fitness in Brazilian children and adolescents, American journal of human biology: the official journal of the Human Biology Council, 29 (2017). [DOI] [PubMed]

[21] Y.C. Huang, R.M. Malina, Body mass index and individual physical fitness tests in Taiwanese youth aged 9-18 years, International Journal of Pediatric Obesity, 5 (2010) 404-411. [DOI] [PubMed]

[22] K.K. Mak, S.Y. Ho, W.S. Lo, G.N. Thomas, A.M. McManus, J.R. Day, T.H. Lam, Health-related physical fitness and weight status in Hong Kong adolescents, BMC Public Health, 10 (2010) 88. [DOI] [PubMed]

[23] H. He, L. Pan, J. Du, F. Liu, Y. Jin, J. Ma, Wang L., P. Jia, Z. Hu, G. Shan, Muscle fitness and its association with body mass index in children and adolescents aged 7–18 years in China: A cross-sectional study, BMC Pediatrics, 19 (2019) 101. [DOI] [PubMed]

[24] Y. Xu, M. Mei, H. Wang, Q. Yan, G. He, Association between Weight Status and Physical Fitness in Chinese Mainland Children and Adolescents: A Cross-Sectional Study, International Journal of Environmental Research and Public Health, 17 (2020) 2468. [DOI] [PubMed]

[25] A. Ladanie, A.M. Schmitt, B. Speich, F. Naudet, A. Agarwal, T.V. Pereira, F. Sclafani, A.K. Herbrand, M. Briel, J. Martin-Liberal, T. Schmid, H. Ewald, J. Ioannidis, H.C. Bucher, B. Kasenda, L.G. Hemkens, Clinical Trial Evidence Supporting US Food and Drug Administration Approval of Novel Cancer Therapies Between 2000 and 2016, JAMA network open, 3 (2020) e2024406. [DOI] [PubMed]

[26] C. Tozlu, B. Ozenne, T.H. Cho, N. Nighoghossian, I.K. Mikkelsen, L. Derex, M. Hermier, S. Pedraza, J. Fiehler, L. Østergaard, Y. Berthezène, J.C. Baron, D. Maucort-Boulch, Comparison of classification methods for tissue outcome after ischaemic stroke, The European Journal of Neuroscience, 50 (2019) 3590-3598. [DOI] [PubMed]

[27] V.P. Lopes, R.M. Malina, R. Gomez-Campos, M. Cossio-Bolaños, M.D. Arruda, E. Hobold, Body mass index and physical fitness in Brazilian adolescents, The Journal of Pediatrics, 21 (2018) 5562-5570. [DOI] [PubMed]

[28] R.J. Kuczmarski, C.L. Ogden, S.S. Guo, L.M. Grummer-Strawn, K.M. Flegal, Z. Mei, R. Wei, L.R. Curtin, A.F. Roche, C.L. Johnson, 2000 CDC Growth Charts for the United States: methods and development, Vital and Health Statistics, 246 (2002) 1-190. [PubMed]

[29] K.T. Chau, J.E. Chan, Regional bias of landslide data in generating susceptibility maps using logistic regression: Case of Hong Kong Island, Landslides, 2 (2005) 280-290. [DOI]

[30] D.R. Helsel, R.M. Hirsch, 2002. Statistical Methods in Water Resources. Reston, VA: Techniques of Water-Resources Investigations of the United States Geological Survey Book 4, Hydrologic Analysis and Interpretation.

[31] H. Midi, S.K. Sarkar, S. Rana, Collinearity diagnostics of binary logistic regression model, Journal of Interdisciplinary Mathematics, 13 (2010) 253-267. [DOI]

[32] J. Fan, S. Upadhye, A. Worster, Understanding receiver operating characteristic (ROC) curves, CJEM, 8 (2006) 19-20. [DOI] [PubMed]

[33] S. Pal, S. Talukdar, Application of Frequency Ratio and Logistic Regression Models for Assessing Physical Wetland Vulnerability in Punarbhaba River Basin of Indo-Bangladesh, Human and Ecological Risk Assessment: An International Journal, 24 (2018) 1291-1311. [DOI]

[34] W. Chen, Y. Li, W. Xue, H. Shahabi, S. Li, H. Hong, X. Wang, H. Lian, S. Zhang, B. Pradhan, B.B. Ahmad, Modeling flood susceptibility using data-driven approaches of naïve Bayes tree, alternating decision tree, and random forest methods, Science of the Total Environment, 701 (2019) 134979. [DOI]

[35] J.F. Hair Jr, W.C. Black, B.J. Babin, R.E. Anderson, Multivariate Data Analysis, 7th Edition, Prentice Hall, Upper Saddle River, 761 (2009).

[36] A. Al-Juaidi, A. Nassar, O. Al-Juaidi, Evaluation of flood susceptibility mapping using logistic regression and GIS conditioning factors, Arabian Journal of Geosciences, 11 (2018) 1-10. [DOI]

[37] J.A. Hanley, B.J. McNeil, The meaning and use of the area under a receiver operating characteristic (ROC) curve, Radiology, 143 (1982) 29-36. [DOI] [PubMed]

[38] P.F. Lee, C.C. Ho, N.W. Kan, D.P. Yeh, Y.C. Chang, Y.J. Li, C.Y. Tseng, X.Y. Hsieh, C.H. Chiu, The Association between Physical Fitness Performance and Abdominal Obesity Risk among Taiwanese Adults: A Cross-Sectional Study, International Journal of Environmental Research and Public Health, 17 (2020) 1722. [DOI] [PubMed]

[39] R.R. Pate, S.G. Trost, M. Dowda, A.E. Ott, D.S. Ward, R. Saunders, G. Felton, Tracking of physical activity, physical inactivity, and health-related physical fitness in rural youth, Pediatric Exercise Science, 11 (1999) 364–376. [DOI]

[40] C.K. Spees, J.M. Scott, C.A. Taylor, Differences in amounts and types of physical activity by obesity status in US adults, American Journal of Health Behavior, 36 (2012) 56-65. [DOI] [PubMed]

[41] C.A. Maher, E. Mire, D.M. Harrington, A.E. Staiano, P.T. Katzmarzyk, The independent and combined associations of physical activity and sedentary behavior with obesity in adults: NHANES 2003-06, Obesity, 21 (2013) E730-E737. [DOI] [PubMed]

Acknowledgement

The authors would like to thank the Office of Physical Education, Chang Jung Christian University for providing the research data.

Funding

No funding was received to carry out this study.

Authors Contribution

Chieh-Lun Hsieh and Yung-Hsiang Hu: developed the study design. Chieh-Lun Hsieh, Cheng-Yen Sun and Yung-Hsiang Hu: undertook the data collection and data analysis. Lorna A. Espeso and Yung-Hsiang Hu: joined supervising the findings of this work. All authors discussed the results, contributed and approved the final version of the manuscript.

Ethics and Informed Consent

The study was conducted according to the guidelines of the Declaration of Helsinki, and Informed consent was obtained from all subjects involved in the study.

Availability of data and material

No additional data are available.

Conflict of interest

The authors declare that they have no conflict of interest.

Does this article screened for similarity?

Yes

About The License