New Trends and Issues Proceedings on Humanities and Social Sciences

Volume 4, Issue 4 (2017) 21-25

ISSN 2421-8030
www.prosoc.eu

Selected Papers of 6th Cyprus International Conference on Educational Research (CYICER-2017), 04-06 May 2017, Acapulco Hotel and Resort Convention Center, North Cyprus.

Investigating the effect of sport branch on predicting the quadriceps strength of athletes using support vector machines

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Suggested Citation:

Akay, F. M., Sow, B., Cetin, E., Yarim, I. & Daneshvar, S. (2017). Investigating the effect of sport branch on predicting the quadriceps strength of athletes using support vector machines. *New Trends and Issues Proceedings on Humanities and Social Sciences.* [Online]. 4(4), pp 21-25. Available from: www.prosoc.eu

Selection and peer review under responsibility of Assoc. Prof. Dr. Cigdem Hursen, Near East University

Abstract

Quadriceps refers to a group of four muscles on the front of the thigh. Adequate quadriceps strength is essential for athletic performance. Quadriceps strength in athletes can be reliably assessed using isokinetic dynamometry. Also, some studies in literature showed the possibility of predicting the quadriceps strength of athletes using machine learning methods within acceptable error rates. The purpose of this study is to investigate the effect of sport branch on quadriceps strength prediction using Support Vector Machine (SVM). The dataset included 70 athletes selected from the College of Physical Education and Sport at Gazi University. The optimal values of SVM parameters have been found by using grid search. The predictor variables gender, age, height, weight and sport branch have been utilized to build sixteen different quadriceps strength prediction models. By carrying out 10-fold cross-validation, the performance of the prediction models has been evaluated by calculating the root mean square errors (RMSE's) and multiple correlation coefficients (R's). The results show that the RMSE's of the prediction models change from 23.31 to 47.78 Nm. The model including the predictor variables gender, height, weight and sport branch yields the lowest RMSE and highest R. One can conclude that sport branch has a profound effect for predicting the quadriceps strength of athletes.

Keywords: Support vector machines, quadriceps, prediction.

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1. Introduction

Taking place on the front of the upper leg, quadriceps refers to a group of four muscles on the front of the thigh. The crucial role of muscular strength and more particularly quadriceps muscle strength in the performance of sport field, as well as in the avoidance of harmful illness is well known (Dervisevic & Hadzic, 2012). In sport fields, in order to achieve success in their respective sports, besides certain very important parameters such as endurance, flexibility and speed, athletes must also develop a high level of muscular strength that is considered to be in close relation with the mentioned parameters. The quadriceps muscles play an important role in jumping and kicking. Therefore quadriceps muscles are in close relation with the performance of athletes.

There exist several techniques that are used to measure the quadriceps muscle strength accurately. Among these techniques, isokinetic testing is the most popular for the direct measurement of the quadriceps muscle strength. Isokinetic exercise is performed by the use of a dynamometer which maintains a constant velocity of movement. Before doing the isokinetic exercises, the participant is stationed in such a way that the body movement to be measured is isolated. The dynamometer is then adjusted at different velocities and the force applied by the participant can be measured over the entire range of movement.

Although the direct measurement of the quadriceps muscle strength using isokinetic test leads to the most accurate results, its utilization is related to several difficulties and limitations. For instance, the equipment required for measuring the quadriceps muscle strength because of its high cost is not yet usually accessible. In addition, directly measuring the quadriceps muscle strength is a time-consuming process and it requires the presence of a qualified and experienced staff. Considering these disadvantages, nowadays predicting the quadriceps muscle strength of athletes using machine learning methods is increasingly adopted.

In the related literature, to the best of our knowledge (Akay et al., 2015) are the two studies that proposed to predict quadriceps muscle strength by utilizing promising machine learning methods. However none of these studies have investigated the effect of sport branch on the prediction of the quadriceps muscle strength of athletes. Therefore the purpose of this study is to investigate the effect of sport branch on quadriceps strength prediction using Support Vector Machine (SVM). The dataset included 70 volunteers who were students at the Department of Physical Education and Sport in Gazi University. The generalization error of the prediction models has been calculated by carrying out 10-fold cross-validation, and the prediction errors have been computed using *RMSE* and *R*. Sixteen prediction models including the predictor variables gender, height, weight, age and sport branch have been developed. The results show that the prediction models that include the combination of predictor variables gender, sport branch, height and weight show better performance than the other prediction models.

2. Generation of the Dataset

In order to carry out this study, 70 students from the College of Physical Education and Sport at Gazi University were involved in the experiments. By using the isokinetic dynamometer (Isomed, 2000) at 60° per second angular velocity, all subjects' right upper leg quadriceps muscle have been measured. The training type known as classic training (CT) which involves light run for 5 minutes has been used in order to measure the quadriceps muscle strength. The dataset included the predictor variables gender, age, height, weight, sport branch and the target variable quadriceps muscle strength. Table 1 shows the minimum, maximum, mean and standard deviation for each variable.

Table 1. Statistics of the dataset

Variables	Minimum	Maximum	Mean	Standard Deviation
Gender	0	1.00	0.36	0.48
Age (Year)	19.00	38.00	21.79	3.06
Height (m)	1.57	2.02	1.71	0.08
Weight (kg)	45.00	93.00	62.04	11.27
Sport Branch	1.00	17.00	9.31	5.03
Quadriceps Muscle Strength (Nm)	61.2	197.7	111.62	36.45

3. Methodology

Using the combinations of predictor variables gender, age, height, weight and sport branch, 16 quadriceps muscle strength prediction models were developed. Each prediction model includes one, two, three, four or five predictor variables. The performance of the SVM-based prediction models has been evaluated using 10-fold cross validation and computing the values of *RMSE* and *R*, whose equations are given as follows:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y - Y')^2} \qquad (1)$$

$$R = \sqrt{1 - \frac{\sum_{i=1}^{n}(Y - Y')^2}{\sum_{i=1}^{n}(Y - \bar{Y})^2}} \qquad (2)$$

where *Y* is the measured value, *Y'* is the predicted value, $\bar{Y}$ is the mean of the measured values and n is the number of samples in a test subset.

SVM has been utilized to build the quadriceps muscle strength prediction models. SVM has been chosen because of several observations gained from the related literature. In general, SVM is known to be better than the other machine learning methods particularly in the domain of sport physiology (M.F Akay et al, 2015) . The accuracy of an SVM model is largely dependent on the values of the model parameters such as C, Gamma and the kernel function. Hence, an effective search algorithm is required to find the optimal values of these parameters. In this study grid search has been used in order to determine the best values of the mentioned parameters and to solve the problem of generalization (C.-W. Hsu et al, 2003). Table 2 shows the list of intervals for values of the utilized parameters for SVM-based prediction models.

Table 2. List of intervals for parameter values

Method	Parameter	Range
SVM	Cost (C)	[0.1 - 5000]
	Epsilon (ε)	[0.0001 - 150]
	Gamma (γ)	[0.001 - 100]

4. Results and Discussion

The validation results of quadriceps muscle strength prediction are given in table 3.

Table 3. Validation results for prediction models with predictor variable sport branch

Models	Predictor variables	*RMSE*	*R*
Model 1	Gender, Sport Branch, Height, Weight	23.31	0.82
Model 2	Gender, Sport Branch, Weight	23.98	0.81
Model 3	Gender, Sport Branch, Height, Weight, Age	24.17	0.80
Model 4	Gender, Sport Branch, Weight, Age	24.28	0.80
Model 5	Gender, Sport Branch, Height, Age	25.42	0.78
Model 6	Gender, Sport Branch, Height	25.58	0.78
Model 7	Gender, Sport Branch, Age	27.70	0.74
Model 8	Gender, Sport Branch	27.74	0.74
Model 9	Sport Branch, Height, Weight	27.91	0.74
Model10	Sport Branch, Height, Weight, Age	28.40	0.73
Model11	Sport Branch, Weight	29.40	0.71
Model12	Sport Branch, Weight, Age	30.19	0.69
Model13	Sport Branch, Height	33.05	0.63
Model14	Sport Branch, Height, Age	33.28	0.63
Model15	Sport Branch, Age	47.17	0.25
Model16	Sport Branch	47.78	0.23

The results show that the prediction model that include predictor variables gender, weight, height and sport branch shows relatively the best performance whereas the prediction model including the predictor variable sport branch exhibits the lowest performance. More particularly, the prediction model including gender, weight, height and sport branch yields the lowest *RMSE* and highest *R* with 23.31 Nm and 0.82 respectively. On the other hand, the prediction model including the predictor variable sport branch yields the highest *RMSE* and lowest *R* with 47.78 Nm and 0.23 respectively. The prediction models including the combination of the predictor variable sport branch and one of the other predictor variables show worst performance. Therefore one can conclude that sport branch has a profound effect for predicting the quadriceps strength of athletes. Figure 1 shows the graph of *RMSE* of the quadriceps muscle strength prediction models.

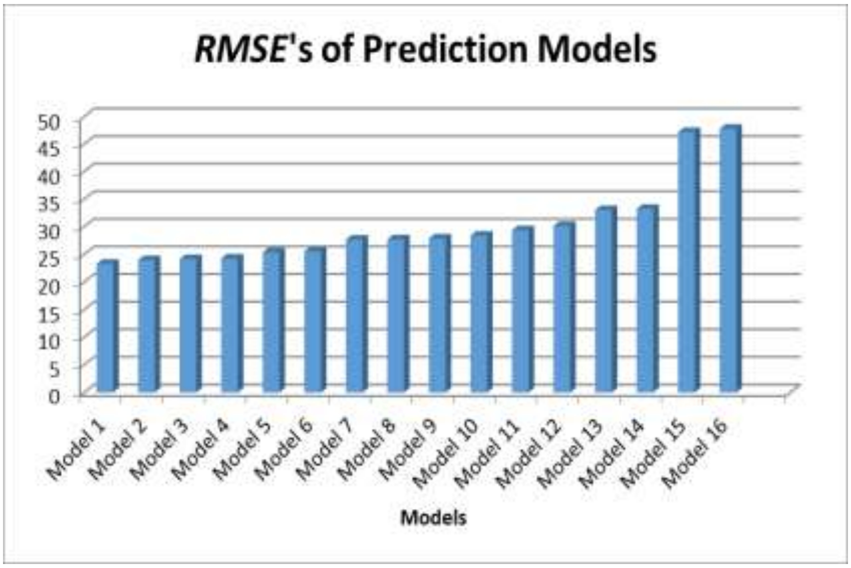

Figure 1. ***RMSE*'s of the quadriceps muscle strength prediction models**

5. Conclusion

In this study combinations of five predictor variables gender, age, height, weight and sport branch have been used to create sixteen models for quadriceps muscle strength prediction. The performance of the prediction models has been calculated by using *RMSE* and *R*. The results reveal that among the prediction models, the prediction model including the variables gender, age, height, weight and sport branch give the lowest *RMSE* and the highest *R*, whilst the prediction model including the predictor variable sport branch only yields the highest *RMSE* and lowest *R*. The results reveal that the prediction models with one or two predictor variables including sport branch show lower performance than prediction models with more than two predictor variables.

Acknowledgment

The authors would like to thank Cukurova University Scientific Research Projects Center for supporting this work under grant no. FYL-2017-7541.

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