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LOAD OPTIMISATION ON WINGATE TEST USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

In supplying the power loss for a period of time that came out during the physical activities, available energy metabolism on leg muscles plays a very important role. In Wingate Test (WT) that's developed for the anaerobic power measurement on leg muscles, a person is demanded to pedal a special bicycle for 30 seconds under a determined load. At first, a unit load (gr/kg) is determined and a friction force, which is proportional to the person's weight, is applied to the pedal-strap.

The friction force that'll be applied to bicycle's pedal-strap must be determined. The determination of the unit load values depends on persons' age, weight, sex, and condition of fitness. Wingate anaerobic test was performed on 35 volunteered and untrained male medical students (mean age 21.3 ± 2.1, mean length 172.1 ± 6.3 cm, mean weight 73.5 ± 8.4 kg) at Physiology Department of Medicine Faculty of Selçuk University. By using exercises results unit load optimisation was realized using artificial neural networks.
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Keywords: *Wingate Test, Peak Power, Mean Power, Fatigue Index, ANN, Load Optimisation.*

1. INTRODUCTION

On application it is quite important to know muscle power, foresighted activity intensity and the effects of over loads on muscle, observing performance increases on sports activities and developing of muscle according to age [1-5]. The energy needed in sports, where huge amount of energy should be used, like short distance run, basketball, football, tennis, and sudden activities is only provided by anaerobic metabolism [3,6].

To determine anaerobic enzyme activities, which play an important role in these types of sports, various invasive methods have been developed. However, these methods are limited in practice, because they need laboratory analysis, which required complex and expensive devices. Therefore researchers have been developed an anaerobic test to use easily in laboratory and area conditions [4,5,7-9].

So far, a satisfying method that can measure anaerobic power in desired accuracy has not been founded [10]. However, there are tests that partly show maximum anaerobic power of person [11]. Wingate Test (WT) has been

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accepted and become a widespread used method to determine anaerobic power [7], because of its proved usefulness, reliability, objectiveness and, practicality [12,13]. WT is a test which is easy to apply and needn't too many devices [14].

2. METHOD

2.1. Wingate Test System

The WT, whose application is quite practical, is defined as spending the power that produced upon the anaerobic energy reactions by the exercises which are done in short time with an intense tempo, following and evaluating the fatigue that occurred after these exercises [7,11-14].

Normally, the muscle energy is provided from the aerobic reaction by using oxygen during the physical activation. If enough amount of oxygen doesn't come to muscles while the physical activation or exercises continues with the same intensity and period, the appearing of an evident energy deficit becomes unavoidable. This energy deficit can be compensated by anaerobic metabolism for a short time. But in this case, the Lactic Acid (LA) that is produced in muscles will cause the muscle fatigue to occur [1,3,15]. The important parameters like Maximum Anaerobic Power (Peak Power, PP), Mean Anaerobic Power (MAP) and Fatigue Index (FI) can easily be obtained by means of applying WT [2, 4 - 9,16].

This study was implemented on the Monark-818 E Bicycle Ergometer, whose calibration is accurate. 12 samples were taken from one full cycling of the pedal of bicycle and WT was applied for 30 seconds. The parameters like PP, MAP and FI were calculated. PP and MAP parameters are in the units of Watt and, FI parameter is given in percent and has no unit. The following method was used to calculate these parameters.

i) Resistive Force :
UL : Unit Load, (In this study 75 gr/kg and 90 gr/kg),
G: The weight of person as kg
R: The friction force that must be applied to the band of the pedal as kg;
R = UL * G

ii) Consumed Power:
UWay(Unit Way): The length of band that is connected to the pedal of the bicycle is 6m. That is, the total length of the band in one tour is 6m. Because 12 sampling was taken by the counter in one tour from the pedal of bicycle, the UWay=0.5m

Way : The distance that passed in 5 sec as m [the number that was counted in 5 sec*UWay]
*Work: The work that is done in 5 sec as kgm (Way*R)*
Power: kgm/sec , obtained by (Way*R) / 5

iii) Peak Power (PP):
HN : The highest number in 6 counting part that lasts 5 sec
PP= HN*Power = (HN)*(Way*R) / 5 kgm/sec
PP = (HN)*(Way*R)*60 / 5 kgm/min

iv) Mean Anaerobic Power (MAP):
TN:The total number after 30 sec (TN_1 + TN_2 +...+ TN_6)
MAP = (TN)*(Way*R)/30 kgm/sec
MAP = (TN)*(Way*R)*60/30 kgm/min

As 1 Watt=6.12 kgm/min, PP and MAP values can be obtained in the units of Watt (W) dividing by 6.12

v) Fatigue Index (FI):
FI : It is described as "Fatigue index in percent",
LN : The Lowest Number in 6 counting part that lasts 5 sec.
The Fatigue index can be calculated from:

$$FI = \frac{HN - LN}{HN} \times 100$$

The block diagram for the WT system and the flow chart of the program that is used to calculate PP, MAP and FI are shown in Fig.1 and Fig.2 respectively.

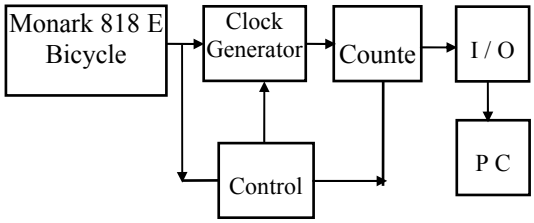

Figure 1. The block Diagram for the Wingate test

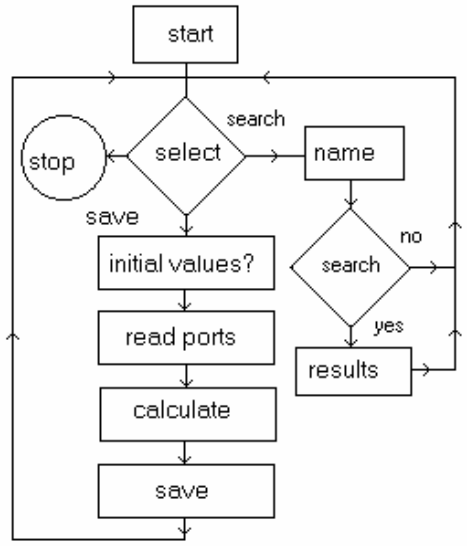

Figure 2. The flow chart of the program

2.2. Defining The Unit Load

A work is done against the load that is applied to the band, which is connected to the pedal of the bicycle, by the person who is used as test subject. The intensity of the load can be modified according to the weight and age of the person. Generally, it is advised that 75 gr is used for ages between 8-16 and 90 gr is used for ages 16 and above [2,7].

Different loads can be used in WT. Though generally 75 gr/kg load is preferred, some researchers have used 86 gr/kg [20], 88 gr/kg [21], 90 gr/kg [21], 95 gr/kg [22] loads. As the peak power and mean power change with relation to the applied load, the selection of the load is important. In addition, sex, age and training state of the person to which the test will be applied are also important [23].

The results taken from the tests those are carried out on 35 volunteers in Physiology Department of the Medicine Faculty in Selçuk University are evaluated in Artificial Neural Networks (ANN) and Unit Load Optimisation is performed according to the age and weight of person and considering whether he smokes, does sports or not. By means of this work, the selection of the load that is applied to the band of the pedal of the Ergometer Bicycle can be done quickly and securely. Furthermore, more meaningful peak power and mean power values are obtained with this optimum load. Fig.3 shows the block diagram of unit load optimisation that is performed by ANN on WT.

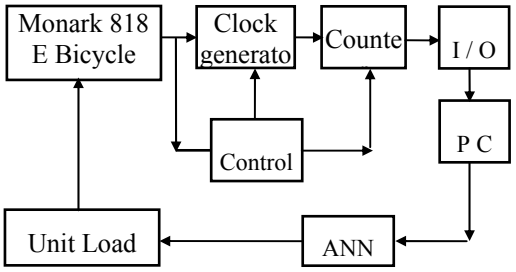

Figure 3. The Unit Load optimisation in ANN on Wingate Test.

2.3. ANN Architecture

How to apply input variables to the ANN is an important problem in this case. The reason is that despite age and weight is objective data, smoking and doing sports is subjective data as they change from person to person. While solving the problem, a criterion was applied to each input separately. That is a grading was done according to the type and weekly frequency of the sport. A grading was also done for the smoking frequency of the person. The same criterion was used in training and test phases of the ANN for all persons who were used as test subjects. As the threshold function in ANN was sigmoid, all inputs were applied to the ANN after normalization.

In this study, an ANN architecture as 4:4:4 feed forward Multi Layer Perceptron was used (Fig.4). The input variables were age, weight, sport, smoke and the output variables were Unit Load, Peak Power, Mean Power and Fatigue Index. The learning rate and momentum coefficient that arranges learning speed were chosen as $\varepsilon = 0.125$ and $\alpha = 0.255$ respectively. The number of pattern sets of the input components were taken as 57. Learning accuracy with 96.7% was obtained after 10000 iterations. For the learning rule, the Generalized Delta Rule that was proposed by Widrow and his student was used [24]. The variation of the learning error with iterations is depicted in Fig.5. The input-output variables that are used in ANN are as follows:

X_0 =The age of the person (Age);
X_1 =Whether the person does sport or not (Sport);
X_2 =Weight of the person (kg);
X_3 =Whether the person smokes or not (Smoke);
Y_0 =The optimum Unit Load that must be applied to the band of the pedal of the bicycle (UL);
Y_1 =The approximate Peak Power that the person can reach (PP);
Y_2 =The approximate Mean Power that the person can reach (MP);
Y_3 = The percentage of Fatigue Index (FI);

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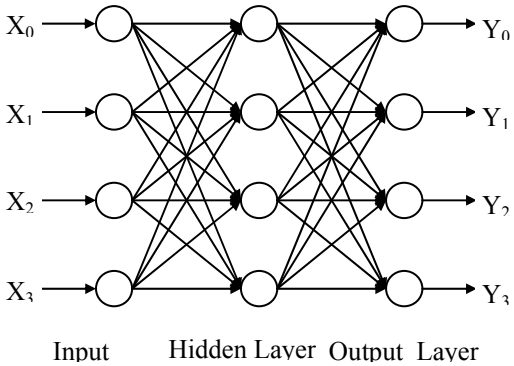

Figure 4. The ANN architecture that is used in the Wingate Test for load optimisation.

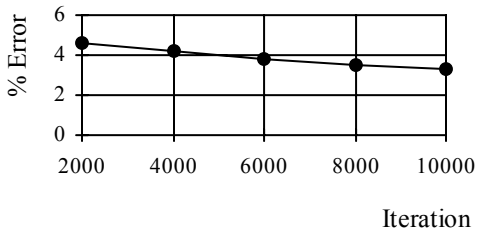

Figure 5. The Training Error versus iteration number.

3. DISCUSSION

The energy metabolism in the leg muscles plays an important role in composing the power loss for a specific time that occurred during the physical activities, which require a special effort. The trainings in different types done for this purpose are one of the factors that play an important role in increasing the effect of the energy metabolism in this direction. Measuring the performance increases periodically, which can be obtained depending on the different types of trainings, and evaluating the measurement results again whenever needed, can be desired.

While doing these evaluations, it was quite beneficial to optimise the Unit Load for obtaining the parameters like PP, MAP, and FI at high values.

REFERENCES

[1] Margaria R., Aghemo P., Rovellie E., "Measurement of muscle power anaerobic in man", J.Appl. Physiol., 21, 1662-4, 1966.

[2] Dotan R., Bar-Or O, "Load of optimization for the Wingate anaerobic test", Eur.J.Appl.Physiol., 51,409-17, Israel, 1983

[3] Katz A., Sahlin K., Henriksson J., "Muscle ATP turn over rate during isometric contraction in humans", J.Apple.Physiol.,60, 1839-42 ,1986.

[4] Patton J.F, Murphy M.M, Frederick F.A, "Maximal power outputs during the wingate anaerobic test", Int.J.Sports Med., 6, 82-85, NewYork, 1985.

[5] Hawleyy J.A, Williams M.M, Hamling G.C, Walsch R.M, "Effects of atask a specific warm-up on anaerobic power", Br. J.Sp.Med.Vol.23, No.4, 233-6. New Zealand. 1989.

[6] Tharp G.D, Newhouse R.K, Uffelman L., "Thorland W.G, Johnson G.O, Comparison of sprint and run times with performance on the Wingate anaerobik test", Res Q. , 56: 73-6, 1985.

[7] Patton J.F., Duggan A., "An evaluation of tests of anaerobic power. Aviat Space Environ Med.", 58:237-42, 1987

[8] Maud P. J, Shultz B. B, "Norms for the Wingate anaerobic test with comparison to another similar tests", Research Quarterly for Exersise and Sport, Vol.60, No.2,144-51. Eastern Washington Üniversity. 1989.

[9] Nebelsick-Gullet L.J., Housh T.J., Johnson G.O., "Bauge S.M., A comparison between methods of measuring anaerobic work capacity", Ergonomics, 31:1413-9,1988.

[10] Manning J.M., Dooly-Manning C., Perrin D.H., "Factor analysis of various anaerobic power tests", J. Sports Med., 28:138-44, 1988.

[11] Astrand P.O., Rodahl K., "Textbook of Work Physiology. 3rd ed." McGraw Hill, 384, Singapore, 1986.

[12] Inbar O, Ayalon A, Bar-Or O, "Relationship between tests of anaerobic capacity and power", Israel J. Med. Sci., 10, 290-1, 1974.

[13] Bar-Or O., Dotan R., Inbar O., "A 30-sec. all-out ergometric test: its reliability and validity for anaerobic capacity", Israel J. Med. Sci. , 13:326-7, 1977.

[14] Francis K., "Methods of anaerobic power assestment (A statistical program for the IBM PC)", Physical Ther. , 67, 270-5,1987.

[15] Gökbel H, Dölek Ç, Bediz C.Ş, Kara M, Vural H., "The relationship of lactic acid and total testosterone levels after the Wingate test", Türk J. Med. Sci. , 26, 1996.

[16] Gökbel H, Çalişkan S, Özbay Y, Bediz C.Ş, "The Anaerobic Power values in Wingate Tests with two different loads", Journal of Sports Science, 4,10-16, 1993.

[17] Froese E.A., Houston M.E., "Performance during the Wingate test and muscle morphology in males and females", Int. J. Sports Med., 8, 35-9, 1987.

[18] Horswill C.A., Scott J.R., Galea P., "Comparison of maximal aerobic power, maximum anaerobic power, and skinfold thickness of elite and nonelite junior wrestlers", Int. J. Sports Med., 10, 165-8, 1989.

[19] Murphy M.M, Patton J.F, Frederick F.P, "Comparative anaerobik power of men and women", Aviat Space Environ Med., 57, 636-41,1986

[20] Baltzopoulos V, Eston R.G, Maclaren D.A., "Comparision of power outputs on the Wingate test and on a test using an isokinetic device", Ergonomics, 31, 1693-9,1988.

[21] Scott C.B., Roby F.B., Lohman T.G., Bunt J.C., "The maximally accumulated oxygen deficits as an indicator of anaerobic capacity", Med.Sci.Sports Exerc, 23, 618-24, 1991.

[22] Hackney A.C., Shaw J.M., Hodgdon J.A., Coyne J.T, "Kelleher D.L, Cold exposure during military operation : effects on anaerobic performance", J. Appl. Physiology, 71, 125-30, 1991.

[23] Bar-Or O., "The Wingate anaerobic test: An update on methodology, reliability and validity", Sports Med., 4, 381-94,1987.

[24] Widrow B. and Lehr M. A., "30 Years of Adaptive Neural Networks: Perceptron, Madaline, and Backpropagation", Proceedings of the IEEE, vol.78, no:9, pp.1417-1439, September, 1990.

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