International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:8, No:8, 2014

Using Fuzzy Logic Decision Support System to Predict the Lifted Weight for Students at Weightlifting Class

Ahmed Abdulghani Taha, Mohammad Abdulghani Taha

Abstract**—**This study aims at being acquainted with the using the body fat percentage (%BF) with body Mass Index (BMI) as input parameters in fuzzy logic decision support system to predict properly the lifted weight for students at weightlifting class lift according to his abilities instead of traditional manner. The sample included 53 male students (age = 21.38 ± 0.71 yrs, height (Hgt) = 173.17 ± 5.28 cm, body weight (BW) = 70.34 ± 7.87.6 kg, Body mass index (BMI) 23.42 ± 2.06 kg.m-2, fat mass (FM) = 9.96 ± 3.15 kg and fat percentage (% BF) = 13.98 ± 3.51 %.) experienced the weightlifting class as a credit and has variance at BW, Hgt and BMI and FM. BMI and % BF were taken as input parameters in FUZZY logic whereas the output parameter was the lifted weight (LW). There were statistical differences between LW values before and after using fuzzy logic (Diff 3.55± 2.21, P > 0.001). The percentages of the LW categories proposed by fuzzy logic were 3.77% of students to lift 1.0 fold of their bodies; 50.94% of students to lift 0.95 fold of their bodies; 33.96% of students to lift 0.9 fold of their bodies; 3.77% of students to lift 0.85 fold of their bodies and 7.55% of students to lift 0.8 fold of their bodies. The study concluded that the characteristic changes in body composition experienced by students when undergoing weightlifting could be utilized side by side with the Fuzzy logic decision support system to determine the proper workloads consistent with the abilities of students.

Keywords**—** Fuzzy logic, body mass index, body fat percentage, weightlifting.

I. Introduction

ESTIMATION of performance on basis of body weight (BW) only is widely used in many parts of the world and especially in weightlifting activity for learning, but it is inexact and not healthy manner because it has many risks and may leads to injure. The body weight (BW) does not deal with the height of the subject which the later reflexes the anthropometric measurements affect the technique of the lifted weight (LW). The alternative of BW is Body Mass Index (BMI) which is indicator of the Body size and it is generally considered a good way to determine if a subject is at his healthy weight. Although a relationship between size and performance is obvious and well documented [1], BMI does not directly measure the body fat which influence, from other factors, in performance. In the other hand, the percentage of body fat (% BF) may be the actual measurement of the components of the body but it could not help in dealing with the height as an anthropometric factor. So, the authors suggest using the body fat percentage (%BF) with (BMI) as simple in hand available criteria to give decision how many weights should the student lift according to his abilities derived from his BMI and % BF instead of traditional manner used in colleges of physical Education, full mark for 1 fold LW of body weight. The featured variance in body composition among students when undergoing weightlifting as a credit at College of Physical Education can often have more effects upon the weight lifted when they are dealt with comparing to the body weight alone. So, in this study a combination of BMI and % BF will be used with fuzzy logic system to predict the non-risky weight should be lifted by the student to have full mark at weightlifting class.

Ahmed Abdulghani Taha is with the Human Performance Lab, College of Sport Education, University of Mosul, Iraq (e-mail: ahmed_a_taha@yahoo.com).

Mohammad Abdulghani Taha is with the Software Engineering Department, College of computer science and mathematics, University of Mosul, Mosul, Iraq, (e-mail: m.a.taha@uomosul.edu.iq).

II. Body Fat

The most literature in the field of body composition considers the human body as a two-compartment model consisting of Fat (FM) and Fat-Free (FFM). The fat component can be further divided into *storage fat* and *essential fat*. Storage fat consists of fat stored in the fat cells of the adipose tissues and the fat surrounding the internal organs. Essential fat is that fat found in bone marrow, membranes, the central nervous system, and within the organ tissues themselves [2]. The body fat percentage is the total mass of fat divided by total body mass; body fat includes essential body fat and storage body fat. Essential body fat is necessary to maintain life and reproductive functions. The body fat percentage is a measure of fitness level, since it is the only body measurement which directly calculates a person's relative body composition without regard to height or weight. Fatness generally exerts a negative influence upon fitness. Correlations between fatness and motor fitness are consistently negative. The negative relation is more apparent in those events requiring the projection (jumps), rapid movement (dashes, shuttle runs) and lifting (leg lifts) of the body and the support of the body off the ground (flexed arm hang) [1]. Table I below from the American Council on Exercise shows the categories of % BF for male

III. Body Mass Index (BMI)

Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in meters (kg/m2) (WHO).The widely used body mass index (BMI) provides a measure that allows the comparison of the adiposity of individuals of different heights and weights. While BMI largely increases as adiposity increases, due to differences in body composition, it is not an accurate indicator of body fat; for example, individuals with greater muscle mass will have higher BMIs. The thresholds between "normal" and "overweight" and between "overweight" and "obese" are sometimes disputed for this reason.

TABLE I
NORMS FOR PERCENTAGE BODY FAT (MALE)

Description	Men
Essential fat	2–5%
Athletes	6–13%
Fitness	14–17%
Average	18–24%
Obese	25%+

From ACE Personal Trainers Manual, American council on exercise [3].

Index can be used to derive reliable and accurate measurements of FM in lean and obese adults [5]. However, BMI may not correspond to the same degree of fatness in different populations due, in part; to different body proportions. BMI has also limitations because it is not a measure of body fatness, very muscular individuals often fall into the overweight category when they are not overly fat. Additionally, BMI may place individuals who have lost muscle into the healthy weight category.

Since it deals with weight and height, the BMI of the student determines his optimal positions of the start, squat, rack, and catch.

For limb strength, although muscle CSA could be an ideal index should be used for size or body composition, but a good enough estimate can usually be obtained by anthropometry with corrections for the subcutaneous adipose tissue and bone volume and the non-circularity of the limb [6].

IV. Olympic Weightlifting

Olympic weightlifting is an athletic discipline in the modern Olympic program in which the athlete attempts a maximum-weight single lift of a barbell loaded with weight plates. The two competition lifts in order are the snatch and the clean and jerk. Each weightlifter receives three attempts in each [7].

V. Fuzzy Logic

Fuzzy logic is a form of many-valued logic; it deals with reasoning that is approximate rather than fixed and exact. Compared to traditional binary sets (where variables may take on true or false values), fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false [8].

VI. Methodology

A. Subjects

Male students of the physical education college at university of Mosul served as subjects for this study (n = 53). All subjects had previously experienced the weightlifting class as a credit. Because age is positively related to strength, the sample was chosen intentionally from age 20 to 22 to isolate as possible as the role of neuromuscular maturation and experience in the performance of strength tasks. Sample characteristics (expressed as mean ± SD) included age = 21.38 ± 0.71 yrs, height (Hgt) = 173.17 ± 5.28 cm, body weight (BW) = 70.34 ± 7.87.6 kg, Body mass index (BMI) 23.42 ± 2.06 kg.m-2, fat mass (FM) = 9.96 ± 3.15 kg and fat percentage (% BF) = 13.98 ± 3.51 %. To prove the problem of this study, two independent samples t tests were conducted between the lower and upper quartiles of the variables height; BMI and FM to reveal if there is a performance importance to distinguish among subjects according to these variance. Descriptive data and significance of differences are listed in Table II.

TABLE II
THE INTERNATIONAL CLASSIFICATION OF ADULT UNDERWEIGHT, OVERWEIGHT AND OBESITY ACCORDING TO BMI

Classification	BMI(kg/m2) Principal cut-off points
Underweight	<18.50
Normal range	18.50 - 24.99
Overweight	≥25.00
Pre-obese	25.00 - 29.99
Obese	≥30.00

Source: Adapted from WHO, Global database on Body Mass Index, [4]

TABLE III
DESCRIPTIVE DATA AND SIGNIFICANCE OF DIFFERENCES

	n	Q1	Q2	T-value	P-Value
BW (kg)	13	59.72± 2.31	79.66± 3.11	18.54	0.001
Hgt (cm)	13	166.92 ± 0.954	180.69 ± 2.02	22.26	0.001
BMI (kg.m-2)	13	20.85 ± 0.75	26.16 ± 0.91	16.25	0.001
FM (kg)	13	6.14 ± 1.14	14.08 ± 1.91	12.89	0.001

B. Body Composition

A bioimpedance instrument (TANITA BC 418, Tokyo, Japan) was used to determine fat mass (FM) and body fat Percentage (%BF).

C. Measures Anthropometric

Body weight (kg) and Height (cm) were determined with a certified digital scale (Detecto-Medical, USA). Each subject was measured while in stocking feet. Body mass index (BMI) was calculated as BW/Hgt^2 [10].

D. Fuzzy Logic

The proposed system was build by using MatLab FIS. For proposed FIS, two Input parameters were taken, BMI and % BF, and one parameter as output, LW lifted weight. According to WHO table range of BMI, ASCI table range of %BF and the rank within which the sample lay, the first input parameter has three membership functions (underweight, normal, overweight) as shown in Fig. 1, in addition the second input parameter, % BF included three membership functions (athlete, fitness, average) according to Table II as shown in Fig. 2.

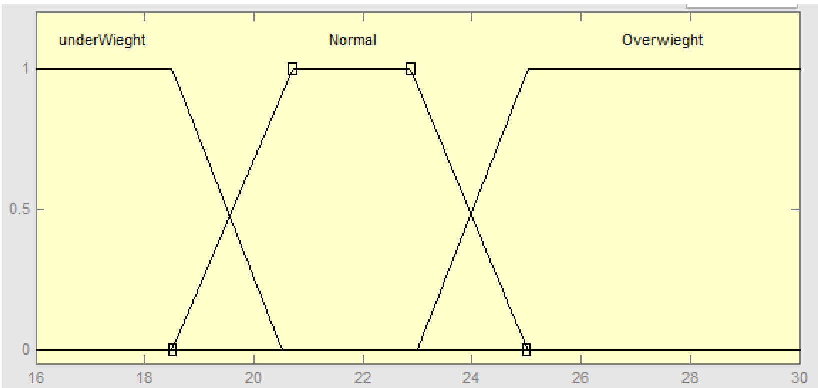

Fig. 1 BMI membership functions

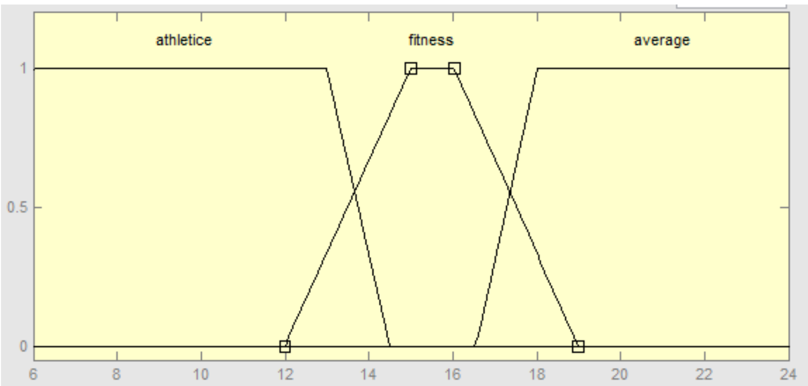

Fig. 2 % BF membership functions

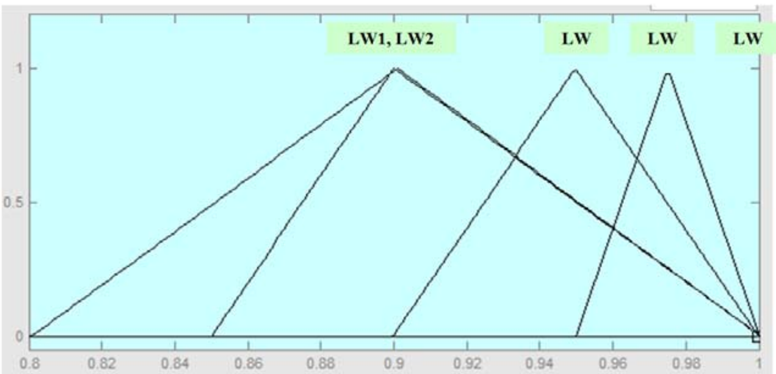

Fig. 3 Output parameter LW membership functions

According to expert, fuzzy output parameter will include 5 membership functions, Lw1-Lw5 which range from 0.8 to 1 and it represents the percentage of weight lifted relative to body weight.

After creating the input and output parameters, building the inference rules were created by the expert and included 9 rules shown in Fig. 4. All the rules and the ranges for membership function can be tuned by expert to gain best results.

if (BMI is Underweight) and (%BF is Athlete) then (LW is LW1) (1)
if (BMI is Underweight) and (%BF is Fitness) then (LW is LW2) (1)
if (BMI is Underweight) and (%BF is average) then (LW is LW1) (1)
if (BMI is Normal) and (%BF is Athlete) then (LW is LW4) (1)
if (BMI is Normal) and (%BF is Fitness) then (LW is LW3) (1)
if (BMI is Normal) and (%BF is Average) then (LW is LW2) (1)
if (BMI is Overweight) and (%BF is Athlete) then (LW is LW5) (1)
if (BMI is Overweight) and (%BF is Fitness) then (LW is LW4) (1)
if (BMI is Overweight) and (%BF is Average) then (LW is LW1) (1)

Fig. 4 Fuzzy logic rules build by expert

Fig. 5 shows the rule viewer for proposed system represented in MatLab FIS. Any input parameter values will generate a crisp value represent the percentage of LW.

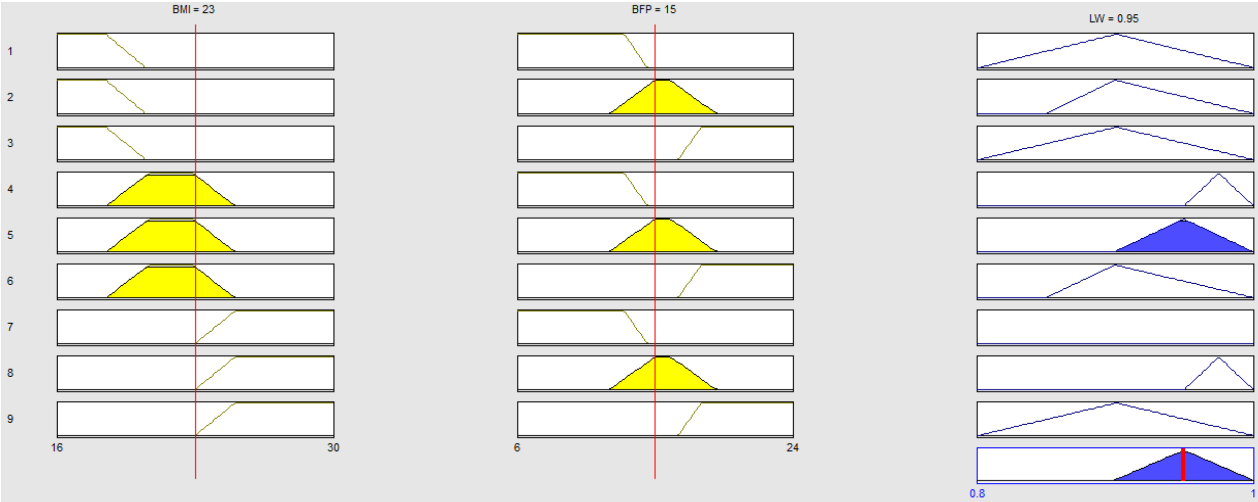

Fig. 5 MatLab rule viewer for proposed system

E. Statistical Analyses

Standard descriptive statistics, using the Statistical software of MINITAB® Release 14.1, were calculated to evaluate the mean characteristics of the participants and variable in the study. Two independent and paired samples t test were used to determine the significance of differences among variables. Microsoft® Office Excel 2003 was use for generating charts. All data are presented as mean ± SD.

VII. Results

There were statistical differences between LW values before and after using Fuzzy logic (Diff 3.55± 2.21, P > 0.001) Table IV. The percentages of the LW categories proposed by fuzzy logic were 3.77% of students to lift 1.0 fold of their bodies; 50.94% of students to lift 0.95 fold of their bodies; 33.96% of students to lift 0.9 fold of their bodies; 3.77% of students to lift 0.85 fold of their bodies and 7.55% of students to lift 0.8 fold of their bodies. Table V.

TABLE IV
Statistical Differences between LW (kg) Values Before and After using Fuzzy Logic

	n	Mean ± SD	T-value	P-Value
Before Fuzzy logic	53	70.34± 7.87		
After Fuzzy logic	53	66.79 ± 7.46	11.71	0.001
Difference	53	3.55± 2.21		

TABLE V
The Percentages of the LW Categories Proposed by Fuzzy Logic

LW from BW		%
1	LW5	3.77
9.5-1.0	LW4	50.94
9.0-1.0	LW3	33.96
8.5-1.0	LW2	3.77
8.0-1.0	LW1	7.55
		100.00

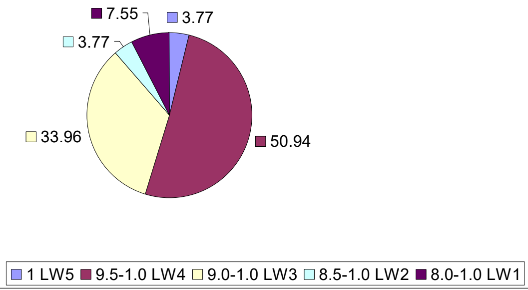

Fig. 5 Pie presentation of lifted weights (%) determined by BMI and %BF using Fuzzy Logic

VIII. Discussion

The main findings of this study were:

i. Using fuzzy logic depending upon BMI and %BF rules to determine LW to score full mark in weightlifting class decrease significantly the value of LW by 3.55± 2.21 kg.
ii. The most percentage of the proposed LW, 50.94%, was in category of students to lift 0.95 fold of their bodies. The second huge percentage of the proposed LW, 33.96, was in category of students to lift 0.9 fold of their bodies. Where as The percentage of the actual LW during lesson to score full mark was just 3.77%.
iii. The fuzzy logic still offer 1 fold of LW for all categories regardless of BMI and % BF which explain for teacher the role of other factors involved, the technique for example and vise versa if the student could not achieve the minimum LW at his category.

The finding of this study consistent with literature suggesting that fitness scores decrease linearly with an increase in fatness [9] and there are correlations of stature and weight with a variety of strength tasks are higher than those for motor fitness Thus, the taller and heavier individual tends to be stronger [10]. The negative relation is more apparent in those events requiring the projection (jumps), rapid movement (dashes, shuttle runs) and lifting (leg lifts) of the body and the support of the body off the ground (flexed arm hang) [10].

The muscular Strength is directly related to cross-sectional area (CSA) of the muscles which reflexes the number and size of the muscle fibers recruited. The number of actin-myosin cross-bridges activated within these fibers determines partially the amount of strength could be developed throughout isometric muscular contraction. It also depends on the available leverage [1].

IX. Conclusion

The characteristic changes in body composition experienced by students when undergoing weightlifting could be utilized side by side with the Fuzzy logic decision support system to determine the proper workloads consistent with the abilities of students.

References

[1] N. G. Norgan, "Anthropometry and physical performance" in Anthropometry: the individual and the population, S.J. Ulijaszek and C.G.N. Mascie-Taylor, Eds, Cambridge University Press, London, 1994.
[2] Brown SP, Miller WC, Eason, JM. Exercise Physiology: Basis of Human Movement in Health and Disease. Philadelphia, PA: Lippincott, Williams and Wilkins; 2006.
[3] ACE Personal Trainers Manual, Bryant CX and Green DJ, Editors. American council on exercise at website: http://www.acefitness.org/acefit/expert-insight-article/3/112/what-are-the-guidelines-for-percentage-of/
[4] WHO, Global database on Body Mass Index, at website: apps.who/bmi.
[5] Garrow, J. S. & Webster, J. Quetelet's Index (W/H2) as a measure of fatness, 1985. International Journal of Obesity 9, 147-53.
[6] Heymsfield, S. B., McManus, C , Smith, J., Stevens, V. & Nixon, D. W. Anthropometric measurement of muscle mass: revised equations for calculating bone-free arm muscle area, 1982. American Journal of Clinical Nutrition 36, 680-90.
[7] (http://en.wikipedia.org/wiki/Olympic_weightlifting)
[8] Novák, Vilém; Perfilieva, Irina; Močkoř, Jiří Mathematical principles of fuzzy logic. The Kluwer International Series in Engineering and Computer Science, 1999, Kluwer Academic Publishers.
[9] Welon, Z., Jury nee, R. & Sliwa, W. Ci§zar nalezny meiczyzn. 1988, Matieraly i Prace Antropologiczne 109, 53-71
[10] Malina, R.M. Anthropometry. In: Physiological Assessment of Human Fitness. P.J. Maud and C. Foster, Eds. Champaign, IL: Human Kinetics, 1995.