Mathematical Modeling in Tracking the Connection Between Anthropometric Characteristics and Motor and Functional Abilities as well as Diet Quality of Female Students Age 14 to 18 Years

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ABSTRACT

Obesity and chronic illnesses connected with it, mark health problems of modern times which arise as consequences of poor diets and insufficient physical activity in everyday life. With the employment of mathematical modeling, it is possible to make a connection between anthropometric measurements values, motor tests and functional capability results on one side, and diet quality of specified population groups on the other. For this study, measurements were carried out in a vocational secondary school and the subjects were female students aged 14 - 18 years (N=63). Data on nutritional status as a body mass index, and fat tissue distribution as WHR were derived from anthropometric characteristics. Students were interviewed individually by an examiner, and a quantitative food frequency questionnaire (Q-FFQ) was used. Collected data included consumption frequency (daily, weekly, monthly, etc.) of foods, regarding different foods groups and cooking/processing methods (fresh, boiled, baked/fried, canned, etc.). Descriptive statistics and regression models were employed in the data analysis. A number of principal food group servings was followed, and varied considerably. The number of *wheat group* servings ranges from 2 to 20/day; the number of *milk and milk drinks group* servings ranges from 0 to 5/day and the number of *fruits* and *vegetables groups* servings ranges from 0 to 15/day while its mean value is only 2,05/day. Because of a wide range of serving sizes, computer programming was employed in modeling and in tracing the relation of all considered parameters. Regression models demonstrated that students' anthropometric data were in positive correlation with their motor and functional abilities as well as with certain food groups consumption. These results confirm the hypothesis that an adequate diet has a positive influence on the motor and functional abilities of individuals which is verified by anthropometric data interaction between nutritional status, described as body mass index, and fat tissue distribution, described as WHR.

Keywords: anthropometric data; diet quality; functional abilities; mathematical modeling; motor abilities

INTRODUCTION

Health and longevity are predominantly specific actions that we conduct ourselves in life. That is why it is important to focus on young people and a proper distribution of macronutrients in their diet to achieve optimal health. When we talk about the impact on eating habits of today's adolescents, we could not talk about only one factor, but a multifactorial influence. Adolescents are vulnerable to influences of the environment; peers in particular, parental home, modern lifestyle, and fast food promotions. With a relatively strong marketing through TV program and the Internet, as well as acceptable prices of fast food, this food is often on the menu of young people. Observing the diet of adolescents, it is extraordinarily evident that the daily energy intake is too high. This is mainly due to predominant presence of foods rich in energy which primarily comes from refined sugars and fats (Karppanen, Mervaala, 2006). According to research of Jureša and associates (2010), longitudinal studies show how poor eating habits acquired in childhood and adolescence, retain in adulthood (Lauer et al., 1993; Freedman et al., 2001) and are reflected through cardiovascular risks increase (Nelson et al., 1992; Recio-Rodriguez et al., 2012). Previous studies, conducted over the decades, show reduction in number of young people engaged in sports or any physical activity, although it is known that both physical activity and/or exercise are important factors in maintaining health (Andersen et al., 2006; Mikkilä et al., 2005).

In addition to proper nutrition, the physical activity is essential in reducing of the risk of excessive body weight, heart disease, stroke, diabetes type II, hypertension, undesirable blood lipid profile, metabolic syndrome, breast cancer and colon cancer, depression as well as osteoporosis (Kalkwarf et al., 2003; Aro et al., 1997). Studies have shown that even an engagement in light physical activities on a daily basis could significantly contribute to daily energy expenditure, which would result in better body composition (Speakman, Selman, 2003; Broeder et al., 1997; Hardman, Stensel, 2003). Of course, people often exercise to create distraction from the daily stress and nervousness. For those a little more advanced exercisers, there is an opportunity to compete and represent certain life challenge (Mišigoj-Duraković, 2008; Peluso, Guerra de Andrade, 2005; Fox, 1999). The aim of this study was to examine the association between motoric and functional abilities as well as the anthropometric parameters with frequency consumption of foods. For this purpose, descriptive statistics and regression models were used. Also, regression models with one or more independent variables were used. Based on the results of the regression analysis, it is possible to get the basic parameters of regression models that could be used for prediction of certain motoric and functional abilities as well as anthropometric parameters, depending on the observed input.

MATERIALS & METHODS

The sample in the current study consisted of female students at secondary medicine school in Split, Croatia. It covers all four grades of the secondary school, and the total number of respondents was 63. The number of measured students according to age is listed in Table 1.
The average age of measured and interviewed subjects is 16.7 years.

Table 1. Distribution of female students according to their age

Age (years)	Number
15	13
16	8
17	26
18	16
total	**63**

Data collection

Following parameters were collected for all subjects:

1. motoric skills (tapping, long jump from place, sit-ups, bending)
2. functional capacity (running for 6 minutes)
3. anthropometric parameters (body height (BH), body weight (BW), percentage of fat (BF), waist and hip circumferences, body mass index (BMI) and waist to hip ratio (WHR))
4. consumption of food from different food groups

Motoric skills measurements were taken in a gym during sport classes. Performances of given tasks, such as tapping, sit-ups, bending and long jump from place were monitored and the results were registered.
Measurement of distance running during 6 minutes (as an example of functional ability) was taken outdoors. Measurements of anthropometric parameters were measured as recommended by World Health Organization (WHO, 1995). The percentage of body fat (% BF) was measured as electrical impedance, using device Omron (BF-306). Daily, weekly and monthly consumption of different foods was evaluated through an interview using quantitative food frequency questionnaire (Q-FFQ). Data collection was performed individually with each student, by an examiner. Collected information included food consumption frequency (daily, weekly & monthly), regarding different foods groups and cooking/processing methods (fresh, boiled, baked/fried, canned…).

Data processing

Descriptive statistics and regression models were employed in the data analysis. A number of principal food group servings was followed, and varied considerably. We assessed the main five steps in a study using statistical methods, which lead to general conclusions, explanations of steps and application of the work as follows: (i) definition, purpose and object of the research, (ii) observation and analysis of collected data grouping, (iii) tabular and graphical data presentation, (iv) application of methods and techniques based on properly selected statistical methods and (v) interpretation of results and conclusions of the analysis. Regression models were applied (the LINEST function) with more input variables (x_k) with a basic form:

$$y = f(x_1, x_2, x_3, \dots, x_k) + e$$

where;

y is the predicted (dependent) variable; x_k is the independent variable with k=1, 2,…, 32, the foods servings consumed per day presented in tables 4 and 5. The representativeness of the model is evaluated by the coefficient of determination which is estimated according Cradock's ranking table (Petz, 2007).

RESULTS & DISCUSSION

All measured data were evaluated as average values with associated standard deviation, which is presented in the tables 2 till 5.

Table 2. Average anthropometric measurements with standard deviations of female students according to their age

Age (years)	**BW** (kg)	**BH** (cm)	**BMI** (kg m^{-2})	**BF** (%)	**WHR**
15	61.2 ± 6.9	171.4 ± 6.4	20.8 ± 1.8	22.1 ± 3.7	$0.73 \pm 3 \cdot 10^{-2}$
16	56.9 ± 6.0	171.3 ± 7.1	19.4 ± 1.1	19.7 ± 2.9	$0.71 \pm 2 \cdot 10^{-2}$
17	59.9 ± 6.3	170.3 ± 5.4	20.7 ± 2.0	20.6 ± 4.2	$0.72 \pm 3 \cdot 10^{-2}$
18	63.4 ± 7.6	167.8 ± 4.4	22.5 ± 2.3	23.3 ± 4.4	$0.73 \pm 3 \cdot 10^{-2}$

Secondly, period of adolescence can be divided into two basic groups; one with girls age from 14 to 15 years, and the other with girls age from 16 to 18 years (Story, 1992). The period of early adolescent years is marked by the formation of attitudes toward their own experiences and procedures. This is why we can say that this life period is crucial for proper formation of attitudes towards preferred diet and beneficial physical activity. During this period, a physical education teacher and a nutritionist would have to point out the basic legality of certain anthropometric characteristics and their relation to health and balanced diet. In addition to proper nutrition, it is necessary to put the emphasis on physical activity in order to help girls of this age to develop their motor and functional abilities, and understand their importance in body development and maintenance of health (Stang, Story, 2005). No significant differences were detected for the anthropometric measurements (table 2) and motoric skills and functional capacity (table 3) of female students with regard to their age, by use of *t-test* (all p-values >0.05) which allowed us to observe all age groups as one cluster.

Table 3. Average values for motoric skills and functional capacity, with standard deviations, of female students according their age

Age	**Motoric skills**				**Functional capacity**
(years)	**Tapping** (no.)	**Long jump (**cm)	**Sit-ups** (no.)	**Bending** (cm)	**Running 6'** (m)
15	36.2 ± 2.8	175.4 ± 16.3	43.1 ± 6.1	76.8 ± 8.9	1102.8 ± 213.7
16	35.4 ± 5.3	199.9 ± 13.9	44.5 ± 10.2	72.7 ± 9.9	1072.5 ± 91.1
17	35.1 ± 3.8	166.3 ± 21.8	41.1 ± 7.0	74.8 ± 10.4	1011.9 ± 137.1
18	35.6 ± 3.6	161.5 ± 17.7	35.0 ± 9.3	74.9 ± 9.9	969.9 ± 156.2

The idea was to show the relationship between anthropometry (table 3) and motoric and functional abilities vs. diet quality of female students' age 14 to 18 years. The relationship of the anthropometry vs. motoric and functional abilities was presented in the work of Šikić (2012). In this work, a strong relationship between the body mass index and sit-ups (R^2=0.990) as well as a relationships between percentage of body fat and running (R^2=0.982) and bending (R^2=0.981) were indicated. This study investigates the relationship of the anthropometry and skills of students with average daily intake of different food, prepared using different methods (table 4&5).

Table 4. Average daily intake of foods from different food groups with standard deviations for female students

Food group	Servings per day
Grains	8.6 ± 3.7
Protein Foods	
Poultry	0.6 ± 0.4
Meat (pork, lamb, beef)	0.6 ± 0.6
Processed meat	0.7 ± 1
Fish	0.3 ± 0.3
Eggs	0.3 ± 0.2
Beans	0.2 ± 0.2
Cheese	1.1 ± 1.6
Milk and milk drinks	1.8 ± 1.1
Fats	
Dairy spread	0.3 ± 0.4
Butter	0.2 ± 0.3
Margarine	0.2 ± 0.4
Vegetables	1.4 ± 1.5
Fruits	2.1 ± 2.2
Others	
Fast food	0.3 ± 0.3
Non-alcoholic drinks	1.8 ± 1.6
Marmalade, honey, chocolate spread	0.7 ± 0.8

Table 5. Average daily intake of foods differently prepared, with standard deviations for female students

Food group	Servings per day
Poultry and products	
boiled	0.2 ± 0.2
roasted, fried, barbecued	0.5 ± 0.3
Meat and products	
boiled	0.2 ± 0.3
roasted, fried, barbecued	0.4 ± 0.5
Fish	
Boiled	0.1 ± 0.2
roasted, fried, barbecued	0.2 ± 0.2
Eggs	
boiled	0.1 ± 0.2
fried	0.2 ± 0.2
Vegetables	
fresh	0.7 ± 0.9
boiled	0.5 ± 0.6
roasted, fried, barbecue	0.2 ± 0.4
Fruits	
fresh	1.8 ± 1.4
dried	0.1 ± 0.6
canned	0.2 ± 0.7

Collected data included food consumption frequency expressed as daily consumption monitoring the cooking/processing method (fresh, boiled, baked/fried, canned). A number of principal food groups servings was followed, and varied considerably. The number of *wheat group* servings ranges from 2 to 20/day; the number of *milk and milk drinks group* servings ranges from 0 to 5/day and the number of *fruits* and *vegetables groups* servings ranges from 0 to 15/day while its mean value is only 2,05/day. Because of a wide range of servings, computer programming was employed in modeling and in tracing the relation between all considered parameters. Regression models, where the dependent variable was the motoric skill or the functional capacity and the independent variables were number of servings from different food groups (where the food was prepared using cooking, roasting, etc.). For all observed motoric and functional parameters, medium-strong to strong links, between independent and dependent variables were established, where the coefficient of determination ranged from 0.4-0.75. Positive correlation with their motoric and functional abilities, as well as with certain food groups consumption, is presented on figure 1. These results confirm the hypothesis that an adequate diet has a positive influence on the motoric and functional abilities of individuals. This is verified by anthropometric data interaction between nutritional status, where the coefficient of determination ranged from 0.15-0.45, which

presents a medium link between the observed variables (Šikić, 2012). The results of this study also point out the necessity of different nutrition regarding different skills and capacities. Figure 1 presents the output variables sit-ups (R^2=0.74) and running (R^2=0.71) as representatives of motoric and functional performance. These results are consistent with the research reported in the study by Prentice and Jebb (2001). According to the coefficient of determination, there is a very weak relationship between the dependent variable WHR and BMI independent variables as well as the percentage of body fat (Šikić, 2012; Prentice, Jebb, 2001). These results are consistent with studies that show how models without free members have a better correlation, but testing representativeness linear regression showed deviations that were not acceptable (Gajdoš et al., 2004).

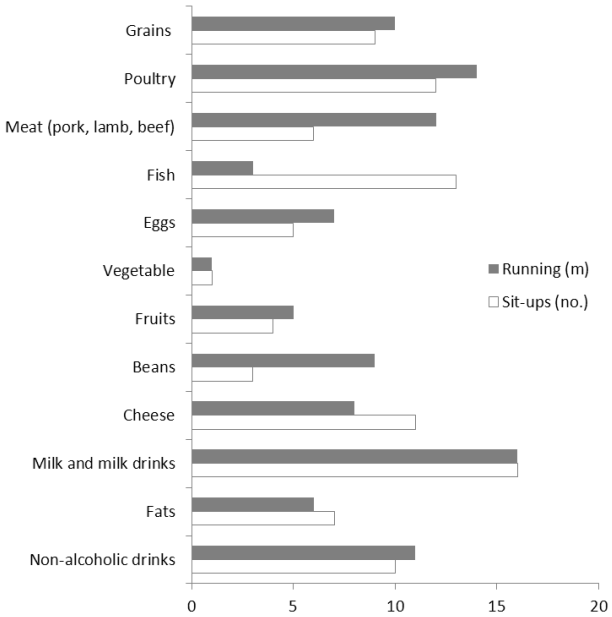

Figure 1. Importance rank of foods groups servings from the regression model coefficients for different motoric and functional performances

It is expected that a person with excessive BW or BMI will not have the same functional and / or motor skills, which is confirmed in other studies (Findak, 1999; Findak et al., 1996; Aslam et al., 2009) as well as with our results. The serving number of fish is significantly different (p=0.002) and more preferable when motoric skills (sit-ups) are the objective. The situation is changing when the functional capacity is the aim – than the number of servings of beans and meats should be increased, allowing more grain consumption which is in accordance with findings of Boulé and co-workers (2005) and Dwyer & Davis (2005) where the exercise training effects the glucose homeostasis and improves health.

CONCLUSION

Set objectives of the study, which showed the relationships between anthropometry and motoric and functional abilities vs. diet quality of female students age 14 to 18 years, were confirmed. But the study indicated pertinence of different foods for different kinds of sports performance. Presented findings are the first step that should be followed by an expansion of the study to a larger number of participants and include different age and gender groups.

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