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MUSCLE STRENGTH IN RELATION TO BODY COMPOSITION IN THE TURKISH MALE NATIONAL JUDO TEAM

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Abstract

The Objectives: The aim of this study was to examine the strength differences in weight categories. For this purpose we have investigated the relationship between body fats and strength of The Turkish National Male Judo Team.

The Methods: Thirty-nine members of The Turkish Male National Judo Team [n=39, age 19.34 ± 2.71 yr, body mass 81.63 ± 21.67 kg, height 175.26 ± 8.67 cm] were participated as subjects. For body composition profiles, body mass, standing height, lower extremity length (LE), skinfold thickness (biceps, triceps, subscapular, thigh, suppraspinale), body fat percentage (BF %) and body mass index (BMI) were measured. Body fat percentage was estimated by using Brozek method. The strength values were measured from leg and back. The relationship between variables was determined by the Pearson Coefficient Correlation at the significance level of $p<0.05$.

The Results: Statistical significant correlations appeared in the leg and back strength with age, height, weight, lower extremity length, BF %, BMI. A negative correlation was found between training history and skinfold thickness. On the other hand, there was no significant correlation between strength values and training history. Also, no correlation was found between weight and skinfold thickness.

Conclusions: As judo is a weight classified sport, the correlation of weight and strength is important. The present study demonstrated that age, height, weight, lower extremity length, BF % and BMI effect leg and back strength. Judo players in higher weight classes present higher BF% and strength.

Keyword: Judo, Anthropometry, Strength, Body Fat Percentage.

Introduction

Judo is a body contact sport with requirements such as strength, judo specific techniques, tactical excellence, motor control and high degree of total body fitness.

Muscle mass is a considerable part of the human body weight. In addition, it has been reported that the muscle strength is highly correlated with muscle mass, muscle structure, body mass and neurophysiological factors (J. Janiak, B. Krawczyk, 1995). Therefore, among equally trained individuals, those with greater body weight demonstrate greater strength (V. M. Zatsiorsky, W.J. Kraemer, 2006). Also, it has been reported that, the correlation between the muscle strength and the lean body mass content in combat athletes were much higher than non-combat athletes (J. Janiak, B. Krawczyk, 1995). On the grounds that the muscle mass is the major determinant of strength, weight classes are designed for strength sports to promote competition between athletes of roughly equal size (L. Burke, 2007).

As judo is a weight classified sport, the correlation of weight and strength is important (M. Takahashi et al., 2005). It has been submitted that elite judoists should have low body fat and high muscle mass percentage (P.N. Ali, P. Hanachi,N.R. Nejad, 2010, E. Franchini, F.B. Del Vecchio et al., 2005, R. Callister, et al., 1991). E. Franchini, M.Y. Takito et al. (2005) reported that muscle mass percentage is about % 45 of body weight in high level judoists. Also, it has been suggested that elite judo athletes had a larger fat-free mass than the non-elite judoists (V. Kankanala, E.A. Gunen, A.S. Igah, 2010; J. Kubo, T. Chishaki, N. Nakamura, 2006).

The aim of this study was to examine the strength differences in weight categories. For this purpose we have investigated the relationship between body fats and strength of The Turkish National Male Judo Team.

Material and Methods

Subjects:

Thirty-five members of Turkish National Male Judo Team participated in the study as subjects. All participants volunteered for the study, after being informed about the procedures of research. The physical characteristics and training history of subjects assessed in training camp in preparation for 2010 European Championship.

The participants were trained athletes (at least 7 years) and practiced between 12 and 20 hr per week (Table2). The subjects were divided in weight categories according to the conventional division into categories (D. Boguszewski, 2009, T. Okada el al., 2007) such as lightweight (-60kg, -66kg, -73kg), middleweight (-81kg,-90kg) and heavyweight (-100kg, and +100kg).

Table 1. The physical parameters of the subjects

	Subjects (M ± SD)
Variables	**Males (n=35)**
Age(years)	19.34 ± 2.71
Height (cm)	175.26 ± 8.67
Weight (kg)	81.50 ± 21.79

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IMC (kg/m^2)	26.19 ± 4.72

IMC, body mass index; M, average; SD, standard deviation; n, number of subjects.

Anthropometrical Measurement:

Body heights were measured to the nearest 0.1 cm by using a Harpenden stadiometer (Holtain. Ltd.). Body weight was measured in minimal cloths to the nearest 0.1 kg by digital scale.

After having body weight, standing height, lower extremity length; skinfold thicknesses were measured at two times from five sites (triceps, biceps, subscapular, thigh, supraspinale) with a Harpenden caliper (Holtain. Ltd.). The average of two readings was recorded. Total body fat percentage was calculated according to equation of Brozek et al. (1963) (W. Jagiello et al. 2007). Body mass index (BMI) was calculated as weight/height^2 and expressed as kg/m^2. All anthropometric measurements were done by the same experienced anthropologist using standard international procedures (ISAK).

Strengths:

After 15 min warm-up exercises including leg, abdomen and back muscles; the subjects performed measurements of maximal muscle strengths. Back and leg isometric strengths were assessed by using a Takei leg dynamometer. For the measurements, subjects were instructed to take position on the platform with the trunk straight and the knees flexed for leg strength (LS) and a stiff leg dead lift position with trunk flexed only slightly forward at the hip joints for back strength (BS). The subjects were not allowed to lean backward on the heels (C.J. Gore, 2000). The best result was recorded after three trials.

Statistics:

SPSS software for windows was used for statistical measurements. Means and standard deviations were calculated to express the results. Mann Whitney U test was performed for analyze the difference between groups. The correlation degree among the variables was evaluated on the basis of the values of the Pearson correlation coefficient, the level of $p<0.05$ and $p<0.01$ being considered significant.

Results

Thirty-five members of The Turkish National Male Judo Team participated in the study as subject and divided by three weight categories.

The training history, including years of active sports-specific training (TY) and hours of total training per week (TH) of the subjects are shown in Table 2. In The Turkish Male National Judo Team, the training year averages of judoists in all weight categories were determined as not less than 7 years.

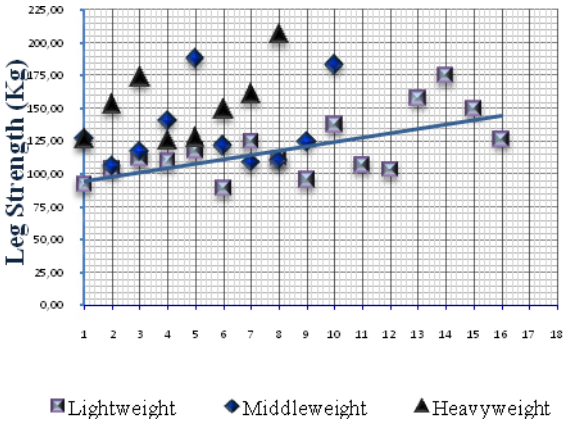

Figure 1. Distribution of leg strength values of subjects in weight categories.

There were significant differences between LW and MW ($p<0.05$) and between LW and HW ($p<0.01$). Also there were significant differences in strength variables (LS and BS) among lightweight (LW), middleweight (MW) and heavyweight (HW) judoists.

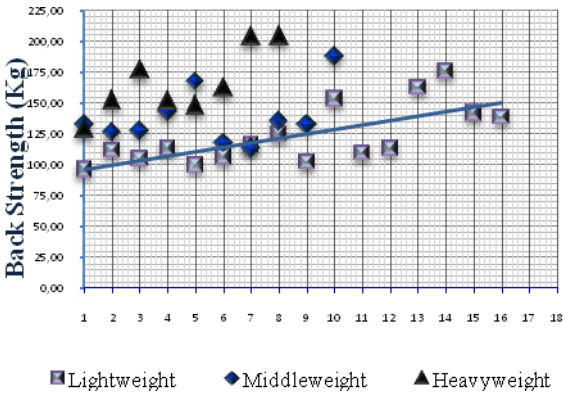

Figure 2. Distribution of back strength values of subjects in weight categories. There were significant differences between all weight categories ($p<0.01$).

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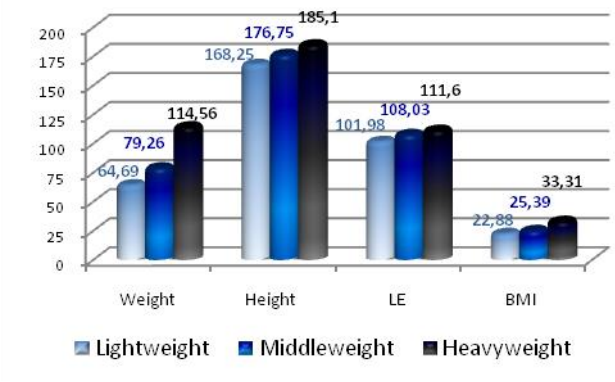

Figure 3. Weights, heights, lower extremity lengths and body mass indexes of subjects.

There were significant differences in weight, height, LE and BMI between all weight categories.

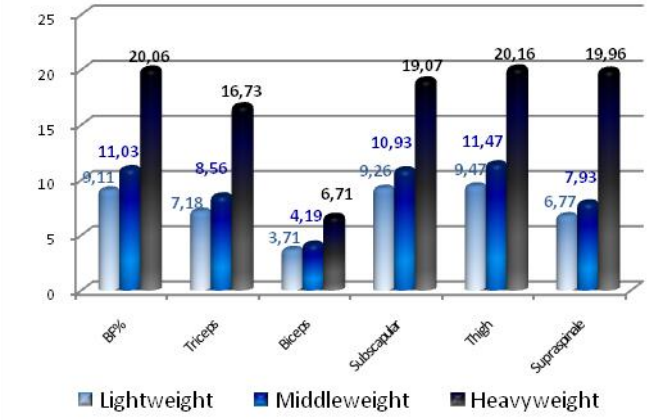

Figure 4. Skinfold measurements and body fat percentages of subjects.

No significant differences ($p>0.05$) were remarked for BF% and skinfold measurements except subscapular ($p<0.05$) between LW and MW. However, when comparing MW and HW, significant differences in skinfold measurements and BF% ($p<0.01$ and $p<0.001$) were detected (Table 3). In addition, there were significant differences between LW and HW in skinfold measurements and BF% ($p<0.001$).

When comparing the weight categories, we were detected significant increase in strength values (LS and BS) parallel to the increase in weight. There were positive correlations between weight and leg strength, weight and back strength and weight and BF% ($p<0.01$).

Table 4 shows the correlation between anthropometrical and strength parameters of The Turkish Male National Judo team. According to the results there was negative correlation between BF% and TY ($p<0.05$). Also, there were positive correlation between age and strength variables (LS and BS) ($p<0.01$).

Table 5 shows the correlation between anthropometrical and strength parameters of LW and MW judoists in The Turkish Male National Team that their BF% was not significantly different (LW and MW, 9.11 ± 1.78 %, 11.03 ± 2.82%, separately, $p>0.05$

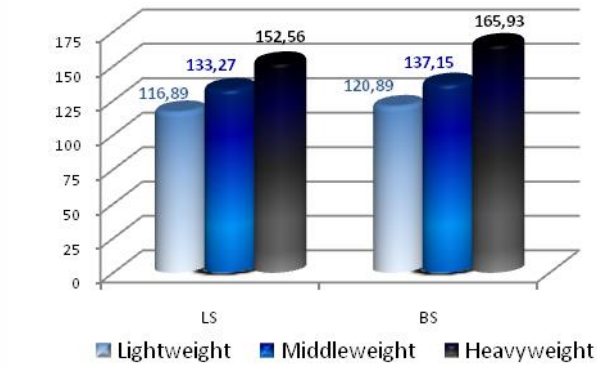

Figure 5. Leg and back strengths of subjects.

Table 2. Training history of subjects by weight categories in The Turkish Male National Judo Team

	Subjects by Weight Categories							
	Lightweight			Middleweight		Heavyweight		
Variables	**-60 kg**	**-66 kg**	**-73 kg**	**-81 kg**	**-90 kg**	**-100 kg**	**+100 kg**	**Total**
Age (year)	19.00 ± 2.64	18.60 ± 2.88	19.88 ± 2.89	18.00 ± 2.16	19.66 ± 2.80	18.75 ± 3.50	20.75 ± 2.75	19.34 ± 2.71
TY (year)	10.00 ± 3.46	9.20 ± 2.86	9.88 ± 2.52	8.75 ± 1.50	10.33 ± 4.27	7.25 ± 4.78	8.25 ± 1.70	9.25 ± 3.05
TH (hour/week)	14.66 ± 4.61	20.00 ± 0.00	18.88 ± 2.26	15.50 ± 5.74	20.16 ± 0.40	15.00 ± 3.46	20.00 ± 0.00	18.20 ± 3.35

Table 3. Anthropometrical and strength parameters of judoists by weight divisions

	Subjects	Mann-Whitney U

	Lightweight (n=14)		Middleweight (n=13)		Heavyweight (n=8)		Lightweight
Variables	**(M ± SD)**	**Z**	**(M ± SD)**	**Z**	**(M ± SD)**	**Z**	**(M ± SD)**
Age (year)	19.42 ± 3.00	0.147	19.00 ± 2.27	0.332	19.75 ± 3.10	0.242	19.42 ± 3.00
TY (year)	9.78 ± 2.86	0.074	9.61 ± 2.27	1.469	7.75 ± 3.37	1.442	9.78 ± 2.86
TH (hour/week)	18.57 ± 2.97	0.220	18.23 ± 3.83	0.823	17.50 ± 3.50	0.741	18.57 ± 2.97
Weight (kg)	64.69 ± 3.67	4.417***	79.26 ± 5.54	3.767***	114.56 ± 20.01	3.823***	64.69 ± 3.67
Height (cm)	168.25 ± 3.35	3.568***	176.75 ± 4.78	2.174*	185.10 ± 9.59	3.210***	168.25 ± 3.35
LE (cm)	101.98 ± 3.81	2.795**	108.03 ± 4.98	1.781	111.60 ± 5.35	3.381***	101.98 ± 3.81
BS (kg)	120.89 ± 24.92	2.525**	137.15 ± 20.68	2.536**	165.93 ± 27.13	2.867**	120.89 ± 24.92
LS (kg)	116.89 ± 24.70	1.990*	133.27 ± 26.23	1.738	152.56 ± 27.94	2.766**	116.89 ± 24.70
Triceps (mm)	7.18 ± 1.61	1.359	8.56 ± 2.78	3.261***	16.73 ± 4.39	3.686***	7.18 ± 1.61
Biceps (mm)	3.71 ± 0.65	1.458	4.19 ± 0.92	3.047**	6.71 ± 1.85	3.620***	3.71 ± 0.65
Subscapular (mm)	9.26 ± 1.36	1.967*	10.93 ± 2.20	3.188***	19.07 ± 7.29	3.619***	9.26 ± 1.36
Thigh (mm)	9.47 ± 2.63	1.359	11.47 ± 4.01	2.753**	20.16 ± 6.64	3.276***	9.47 ± 2.63
Supraspinale (mm)	6.77 ± 1.18	1.262	7.93 ± 2.37	3.260***	19.96 ± 8.48	3.550***	6.77 ± 1.18
BF% (%)	9.11 ± 1.78	1.747	11.03 ± 2.82	3.114**	20.06 ± 6.37	3.276***	9.11 ± 1.78
BMI (kg/m^2)	22.88 ± 1.65	3.057**	25.39 ± 1.77	3.766***	33.31 ± 4.13	3.322***	22.88 ± 1.65

p<0.05*, p<0.01**, p<0.001***

Table 4. Correlation of anthropometrical and strength parameters of judoists

	Pearson Correlation (n=35)													
Variables	**Age**	**TY**	**TH**	**Weight**	**Height**	**LE**	**BS**	**LS**	**Tric.**	**Bic.**	**Subsc.**	**Thigh**	**Supra.**	**BF%**	**BMI**
Age	-														
TY	0.778**	-													
TH	0.102	0.064	-												
Weight	0.192	-0.188	0.084	-											
Height	0.103	-0.045	0.248	0.814**	-										
LE	0.002	-0.071	0.306	0.668**	0.838**	-									
BS	0.501**	0.066	0.105	0.740**	0.543**	0.532**	-								
LS	0.627**	0.183	0.123	0.595**	0.426**	0.350**	0.903**	-							
Triceps	-0.008	-0.303	-0.009	0.860**	0.654**	0.544**	0.459**	0.314	-						
Biceps	-0.038	-0.304	0.060	0.858**	0.665**	0.572**	0.482**	0.279	0.927**	-					
Subscapular	0.143	-0.269	0.120	0.915**	0.648**	0.539**	0.677**	0.511**	0.846**	0.904**	-				
Thigh	-0.164	-0.360*	0.014	0.752**	0.661**	0.554**	0.327	0.164	0.803**	0.739**	0.716**	-			
Supraspinale	0.096	-0.286	0.046	0.911**	0.637**	0.506**	0.611**	0.437**	0.909**	0.931**	0.945**	0.768**	-		
BF%	-0.016	-0.339*	0.072	0.897**	0.708**	0.590**	0.535**	0.358**	0.887**	0.882**	0.920**	0.932**	0.921**	-	
BMI	0.816	-0.253	-0.039	0.945**	0.589**	0.488**	0.735**	0.593**	0.838**	0.819**	0.900**	0.682**	0.902**	0.849**	-

p<0.05*, p<0.01**

Table 5. Correlation of parameters between lightweight and middleweight judoists

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Pearson Correlation (n=27)

Variables	Age	TY	TH	Weight	Height	LE	BS	LS	Tric.	Bic.	Subsc.	Thigh	Supra.	BF%	BMI
Age	-														
TY	0.839**	-													
TH	0.094	-0.023	-												
Weight	0.038	0.021	0.162	-											
Height	-0.172	-0.036	0.213	0.699**	-										
LE	-0.137	-0.044	0.293	0.634**	0.767**	-									
BS	0.510**	0.217	0.113	0.518**	0.187	0.322	-								
LS	0.600**	0.261	0.135	0.443**	0.120	0.157	0.907**	-							
Triceps	-.0.301	-0.092	-0.054	0.466**	0.319	0.456**	-0.125	-0.259	-						
Biceps	-0.442**	-0.188	-0.023	0.438**	0.310	0.479**	-0.152	-0.338	0.820**	-					
Subscapular	0.000	-0.067	0.167	0.728**	0.356	0.463**	0.395**	0.285	0.522**	0.604**	-				
Thigh	-0.316	-0.200	-0.163	0.360	0.352	0.260	-0.220	-0.284	0.644**	0.566**	0.511**	-			
Supraspinale	-0.142	-0.077	-0.090	0.554**	0.191	0.377	0.133	-0.035	0.676**	0.693**	0.742**	0.635**	-		
BF%	-0.228	-0.177	-0.048	0.561**	0.404*	0.380	0.002	-0.089	0.702**	0.558**	0.781**	0.936**	0.766**	-	
BMI	0.191	0.059	0.052	0.825**	0.174	0.266	0.575**	0.520**	0.384*	0.351	0.705**	0.201	0.593**	0.435*	-

$p<0.05$*, $p<0.01$**

Discussion

The aim of this study was to examine the strength differences in weight categories. For this purpose we have investigated the relationship between body fats and strength of The Turkish National Male Judo Team.

Body fat percentage is a very important marker for the assessment of physical fitness especially in weight classified sports. A lower BF% may increase performance by improving the strength to weight ratio (W.D. McArdle, F. I. Katch., V.L. Katch, 2001). It has been indicated that body fat has significant inverse association with strength and muscle quality (A.B. Newman, et al., 2003). Researchers reported that elite judoists except for the heavyweight ones have generally low body fat (E. Franchini et al., 2005, R. Almansba et al., 2007). It has been reported that lighter categories have a higher performance of lean muscle mass with respect to the heaviest (R.E. Molina, et al. 2009).

We found that the BF% of the elite Turkish Judoists increase in proportion to their weight ($P_{x,y}$:0.897, $p<0.01$). And BF% values were found for all weight categories are similar to those found in other studies with elite judoists. The means of the BF% for LW, MW and HW were 9.11 ± 1.78 %, 11.03 ± 2.82 % and 20.06 ± 6.37 %, respectively. Several studies (R. Almansba et al., 2010, S. Sterkowicz et al., 1999, E. Franchini et al., 2007, K. Sterkowicz-Przybycien, R. Almansba, 2010) showed that BF% levels for elite male judoists in the range of % 10-15, similarly with our findings. R. Almansba et al. (2010) reported that the BF% of Algerian Olympic Judoists were 12.28 ± 4.16 %. Ş.S. Balcı measured the Turkish male judoists in The Youth National Team aged 18.13 ± 0.77 years and he reported BF% such as 12.38 ± 8.95 % for 80.59 ± 13.43 kg weighted judoists. D.A. Santos et al. (2010) reported body fat percentage 9.2 ± 4.1 % at the period of stability and 8.0 ± 3.8 % prior to competition for elite male judoists. E. Franchini et al (2007) compared the morphological and functional characteristics of the male judo players of the Brazilian Team A with the judo players of Team B and C. They found BF% 11.4 ± 8.4% for Team A and 10.1 ± 5.7% for Team B and C.

Since judo is rather a grappling martial art to throw the component, BMI has a significant impact on judo players (J. Pedro, 2001). In our research we found that elite male judo players have 22.88 ± 1.65 kg/m^2, 25.39 ± 1.77 kg/m^2 and 33.31 ± 4.13 kg/m^2 BMI values for LW, MW and HW, separately. According to our results, P.J. Nande, V. Mudafale

and S.A. Vali (2009) reported BMI value such as 21.6 ± 2.0 kg/m^2 for lightweight judoists (61.2 ± 6.3 kg). R. Almansba et al. (2010) reported BMI value 29.32 ± 6.30 kg/m^2 for 91.85 ± 25.06 kg weighted judoists. Earlier research on 27 elite male judoists (D.A. Santos et al., 2010) notified BMI as 23.6 ± 2.3 kg/m^2.

Muscle strength is highly correlated with lean body mass. Among trained individuals with a similar body percentage, those with greater body weight demonstrate greater strength (V. M. Zatsiorsky, W.J. Kraemer, 2006). Therefore, in weight classified sports such as judo, BMI and strength correlation has importance. In our study, we found a positive correlation between BMI and strength variables. We found leg strength values 116.89 ± 24.70 kg, 133.27 ± 26.23 kg and 152.56 ± 27.94 kg for LW, MW and HW, separately.

When we compare the groups that their BF% was not significantly different (LW and MW, 9.11 ± 1.78 %, 11.03 ± 2.82%, separately, $p>0.05$), a positive correlation revealed between BMI & leg strength ($P_{x,y}$:0.520, $p<0.01$) and BMI and back strength ($P_{x,y}$:0.575, $p<0.01$). Concurring with several other authors (J. Kubo, 2006, E. Franchini, 2007), we found that the strength variables increases in proportion to their BMI ($p<0.01$).

Conclusion

In this study, some anthropometrical variables, and strength levels of The Turkish Male National Judo Team were characterized. It was found that BF% of the elite Turkish Judoists increased in proportion to their weight. Also, we determined that leg strength and back strength were correlated with body weight and body mass index. Thus, it can be said that decreasing BF% and increasing fat-free mass cause the strength variables for the same weight category to increase. However, as much as gaining strength and body fitness, judo specific techniques and tactics are also important for predicting sport performance.

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References

ALI, P.N., HANACHI,P., NEJAD, N.R., 2010, *The Relation of Body Fats, Anthropometric Factor and Physiological Functions of Iranian Female National Judo Team,* Modern Applied Science, 4(6):25-9.

ALMANSBA, R., FRANCHINI, E., and STERKOWICZ, S., 2007, *An Uchi-komi With Load, a Physiological Approach of a New Special Judo Test Proposal,* Science and Sports, 22(5):216-23.

ALMANSBA, R., STERKOWICZ, S., BELKACEM, R., et al., 2010, *Anthropometrical and Physiological Profiles of the Algerian Olympic Judoists,* Archives of Budo, 6(4):185-93.

BALCI, Ş.S., 2002, *The measurements of Some Anthropometric Characteristics and Determination of Somatotypes of Youth Turkish National Judo Team*, Master Thesis, Sağlık Bilimleri Enstitüsü, Selçuk Üniversitesi, Konya

BOGUSZEWSKI, D., 2009, *Defensive Actions of Contestants during Polish Judo Championships in the Years 2005-2008,* Baltic Journal of Health and Physical Activity, 1(2):111-7.

BROZEK, J., GRANDE, F., ANDERSON, J.T., KEYS,A., 1963, *Densiometric Analysis of Body Composition: Revision of Some Quantitative Assumptions,* Annals of the New York Academy of Sciences, 26(110):113-40.

BURKE,L., 2007, *Practical Sports Nutrition,* British Journal of Nutrition, Human Kinetics, USA.

CALLISTER, R., CALLISTER, R.J., STARON, R.S. et al., 1991, *Physiological Characteristics of Elite Judo Athletes,* International Journal of Sports Medicine, 12(2):196-203.

FRANCHINI, E., DEL VECCHIO, F.B., MATSUSHIGUE, K.A., ARTIOLI, G.G., 2005, *Physiological Profiles of Elite Judo Athletes,* Sports Medicine, 41(2):147-66.

FRANCHINI, E., NUNES, A.V., MORAES, J.M., VECCHIO, F.B., 2007, *Physical Fitness and Anthropometrical Profile of the Brazilian Male Judo Team*, Journal of Physiological Anthtropometry,26(2): 59-67.

FRANCHINI, E., TAKITO, M.Y., BERTUZZİ, R.C.M., 2005, *Morphological, Physiological and Technical Variables in High- Level College Judoists,* Archives of Budo, 1:1-7.

GORE,C.J., 2000, *Physiological Tests For Elite Athlete,* Human Kinetics, Champaign, USA.

JAGIELLO, W., KALINA, R.M., KOROBIELNIKOW, G., 2007, *Morphological Diversification of Female Judo Athletes,* Archives of Budo, 3:27-34.

JANIAK,J., KRAWCZYK,B., 1995, *Relationships Between Muscle Force and Total or Lean Body Mass in Highly Experienced Combat Athletes,* Biology of Sports, 12(2):107-11.

KANKANALA, V., GUNEN, E.A., IGAH, A.S., 2010, *Anthropometric Characteristics of Selected Combat Athletic Groups,* British Journal of Sports Medicine, 44(Suppl 1):38.

KUBO, J., CHISHAKI,T., NAKAMURA,N. et al., 2006, *Differences in Fat-Free Mass and Muscle Thicknesses at Various Sites According to Performance Level Among Judo Athletes,* Journal of Strength and Conditioning Research, 20(3):654-57.

MCARDLE, W.D., KATCH, F.I., KATCH, V.L. 2001, *Exercise Physiology: Energy, Nutrition, and Human Performance*, 5th Ed., Lippincott Williams & Wilkins, Philadelphia.

MOLINA, R. E., RODRIGUEZ-RUIZ, S., FERNANDEZ-SANTAELLA, C., et al., 2009, *Differences among weight categories of elite judoists: dietary restrictions, food craving and bulimic symptoms,* 6th International Science of Judo Symposium, 25th August, Rottergam.

NANDE, P. J., MUDAFALE, V., VALI, S.A., 2009, *Anthropometric Profile of Female and Male Players Engaged in Different Sports Disciplines,* Archives of Budo, 6(4):185-93.

NEWMAN, A.B., HAGGERTY, C.L., GOODPASTER, B. et al., 2003, *Strength and Muscle Quality in a Well-Functioning Cohort of Older Adults: The Health, Aging and Body Composition Study,* Journal of the American Geriatrics Society, 51(3):323-30.

OKADA, T., NAKAZATO, K., IWAI, K. et al., 2007, *Body Mass, Nonspecific Low Back Pain, and Anatomical Changes in the Lumbar Spine in Judo Athletes,* The Journal of Orthopaedic and Sports Physical Therapy, 37(11):688-93.

PEDRO, J., DURBIN, W., 2001, *Judo Techniques & Tactics*, Human Kinetics, Champaign, USA.

SANTOS, D.A., SILVA, A.M., MATIAS, C.N. et al., 2010, *Accuracy of DXA in estimating body composition changes in elite athletes using a four compartment monel as the reference method,* Nutrition and Metabolism, 7:22.

STERKOWICZ, S., ZUCHOWICZ, A., KUBICA, R., 1999, *Levels of Anaerobic and Aerobic Capacity Indices and Results for the special Fitness Test in Judo Competitors,* Journal of Human Kinetics, 2:115-35.

STERKOWICZ-PRZYBYCIEN, K., ALMANSBA, R., 2011, *Sexual Dimorphism of Anthropometrical Measurements in Judoists vs Untrained Subject,* Science & Sports, Article in press, accepted 9 December 2010.

TAKAHASHI, M., TAKAHASHI, R., TAKAHASHI, J. et al., 2005, *Mastering Judo*, Human Kinetics, Champaign, USA.

ZATSIORSKY, V.M., KRAEMER, W.J., 2006, *Science and Practice of Strength Training*, Human Kinetics, Champaign, USA.