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# Impact of one year judo training on body symmetries in youth judokas

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A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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## Abstract

**Background & Study Aim:** Anthropometric status of youth judokas is an important factor in the process of maturation and sport development from cadet to senior judo athletes. Training process influences the body in different proportions, therefore a regular screening is recommended to monitor the youth athlete development and to give regular feedback to coaches about their training plans. The aim of present study was the status of the body symmetries in youth judokas during one year training period.

**Material & Methods:** Youth Slovenian male judokas (n = 7), age: 14.33 ±0.64 years; height: 171.01 ±9.69 cm; weight: 62.99 ±8.97 kg, were recruited for this study. 3D anthropometric measurement of the judokas' bodies was performed by the 3D body scanner NX-16 ([TC]2, Cary, North Carolina, USA). With software, we extracted values of 17 paired variables. Shapiro-Wilk`s test was used to check the data for normality of distribution. Afterword's for determination of differences in symmetries we used a paired *t*-test with statistical significance set at $p \leq 0.05$.

**Results:** Body asymmetries in year 2015 showed 3 statistically significant differences; forearm girth $t_{(6)} = 3.41$, $p = 0.01$, mid-thigh girt $t_{(6)} = 3.26$, $p = 0.02$, calf girth $t_{(6)} = 3.73$, $p = 0.03$. In year 2016 we found two statistically significant differences; elbow girth $t_{(6)} = 2.76$, $p = 0.03$, forearm girth $t_{(6)} = 3.05$, $p = 0.02$. From year 2015 to 2016 the youth judokas body dimensions from 17 paired variables (total of 34 variables) were statistically greater in 18 variables.

**Conclusions:** One year of intense training has a big impact on a youth judokas body. With the help of the modern technology and sports testing we can use the acquired data and guide the training process in the way that can lower the occurrence of injuries but still develop the aimed goals, which are connected with better agility, power and better technique. But if we intentionally disregard the acquired data the occurrence of body asymmetries that can lead to injuries is imminent. Therefore, the usage of sports testing and especially useful interpretation of data is necessary in combination with additional education of judo coaches.

**Key words:** 3D scanning • anthropometry • combat sports • condition

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## INTRODUCTION

Judo is a dynamic, high-intensity intermittent combat sport, where a considerable number of different anthropological dimensions alongside excellent level of physical fitness and physical conditioning plays an important role in the final sport result [1-3]. Therefore, if a top result is aimed at, accurate data of the characteristic anthropologic influence on the final result are required [1, 4].

Morphological differences are determined by the genotype predispositions [5-7] and the form of body load alongside with general conditions and rules which apply to the given sport discipline e.g. type of the equipment, clothes or even trainers or their lack [7]. Relatively often results of a long-lasting training are morphological asymmetry and body injuries, which also have a negative influence on everyday life [7-9]. Concerning these data, it seems important to analyse this morphological differences of subjects with regard to their sport discipline and training specificity [7].

Although the human body is bilaterally symmetrical, there are distinct asymmetries in morphology which are apparent in children and adults [10], and which are especially apparent in comparisons of the preferred and non-preferred limbs of non-athletes and athletes engaged in extreme unilateral activities [11]. Asymmetries also tend to be more pronounced in adults than in children [10]. The adolescent growth spurt varies considerably in timing, tempo and duration among individuals. Allowing for this variation, peak height velocity rather than chronological age has been used to characterize changes in size, body composition and performance relative to the adolescent spurt in height [12, 13]. Values of estimated peak height velocity in the sample of European boys is in the range 13.8 to 14.3 years [14].

In judo, anthropometry as a classical method of body measurement was often used [15-17] but several research have shown that the application of 3D body scanners has been increasingly widely used in judo [17-19], due to its good metric accuracy, non-invasiveness and fast functioning [20-22].

The aim of present study was the status of the body symmetries in youth judokas during one year training period.

**Anthropometric** – *adjective* used for referring to statistical data that concerns the human body [29].

**Anthropometry** – noun the gathering of physical data from people for the purposes of statistical analysis [29].

**Condition –** noun 1. the particular state of someone or something 2. a particular illness, injury or disorder; verb to undertake a fitness plan to improve general health, appearance or physical performance [29].

**Combat sports** – the group of sports disciplines, in which the gist of the competition is the direct clash of two competing athletes. They are affiliated to the national and international sports organizations in order to carry out official competition, classification, etc. ("every combat sport is martial arts but not vice versa" [30, p.18]).

**Kata** – predetermined and choreographed physical exercises, which together with free exercises (randori), lectures (kōgi) and discussions (mondō) form the four critical pillars of Kōdōkan jūdō educatinn [31].

**Kumi kata** – gripping methods (is one of the most important elements of modern judo, establishing a good grip and negating your opponents grip can be what wins or loses you a match).

**Tokui waza** – is a special technique that the judoka mostly relies on and most frequently scores an ippon.

**Tokui-waza** – "favourite" or "best" technique. It's the throw that fits naturally to athlete body type.

## MATERIALS AND METHODS

### Participants

Seven trained young male judokas at beginning of study: age 14.33 ±0.64 years, height 171.01 ±9.69 cm, body mass 62.99 ±8.97 kg; and at the end of the study: age 15.53 ±0.64 years, height 176.51 ±9.71 cm, body mass 72.01 ±7.25 kg with national and international competitive experiences participated in the study. All subjects were right hand dominant and are competing in cadet and/or junior age category.

### Data collection

Anthropometric 3D measurement of judokas body was performed by the 3D body scanner (3D BS) NX-16 ([TC]2, Cary, North Carolina, USA). The 3D BS NX-16 has been validated against classical anthropometry [23]. The NX-16 utilizes a non-invasive scanning method to produce a true to scale 3D body model in 8 seconds, which uses photogrammetry technology (white light) with 32 cameras to produce raw photonic point cloud data 3D body image. That 3D cloud data image allows for automatic landmark recognition as well as electronic tape measurements.

Before measurements full calibration of the NX-16 scanner was made, with the acceptable range of the accuracy of circumferences standard deviation of 0.577 mm. Subjects were instructed to remove all jewellery and clothes. They entered the scanner barefooted and in form-fitting bright colour underwear. They stood in a standardized position, with their feet located on landmarks on the scanner's floor (feet set straight, not inwards or outwards), grabbing the handles inside of the scanner with a natural standing posture (shoulders not elevated, elbows stretched, upright position of the back, chin slightly lifted). A 3D Body Measurement System Version 7.4.1 software was used to create the initial point cloud that was then processed into a 3D body model from which customized measurements could be extracted. A multi-scan option with three consecutive scans was used to obtain the data which gave us one merged file with means of all three consecutive scans. Scanning of three consecutive scans lasted 24 s and subjects were instructed to remain still during the scan.

With software we extracted values of 17 paired variables: left (L) and right (R) armscye girth, L-R straight arm length, L-R upper arm girth, L-R elbow girth, L-R forearm girth, L-R wrist girth, L-R

side height waist to floor, L-R outside leg length, L-R thigh length, L-R thigh girth, L-R mid-thigh height, L-R mid-thigh girt, L-R knee height, L-R knee girth and L-R calf girth, which were used and described by [17].

Body fat %, lean mass, skeletal muscle mass and body weight was measured by octopolar bioimpedance InBody 720 (Biospace, Seoul, Korea). Body height was measured by the GPM Switzerland) anthropometer.

Ethical approval of the current study was granted by the local Ethics Committee. Measurements were conducted in a Physiological Laboratory of Faculty of Sports, University of Ljubljana, Slovenia.

### Statistical analysis

Paired samples *t*-test was performed to compare the differences between left/right side and between initial and final measurement. Prior to conducting Paired-Samples *t*-test we performed Shapiro-Wilk`s test to check whether the data was normally distributed (p>0.05). All data were analysed with the SPSS 22.0 (SPSS Inc., Chicago, USA) and Windows Excel 2013 (Microsoft Corporation, Redmond, USA). The level of statistical significance was set a priori at p≤0.05.

## RESULTS

All of our descriptive variables have significantly increased after the initial testing, except for body mass fat and it's percent (p>0.05). Participants have grown for 5.5 cm (from 171.01 ±9.69 to 176.51±9.71 cm) and gained substantial body weight (more than 9 kg) in a period of one year. Lean body mass have also increased during this period from 24.52 ±4.45 kg to 28.20 ±4.34 kg (Table 1).

Significant difference in 2015 measurements was found in forearm girth (p = 0.01), mid-thigh girth (p = 0.02) and calf girth (p = 0.03), while the statistically significant difference in 2016 measurements was found in forearm girth (p = 0.02) and elbow girth (p = 0.03) (Table 2).

Significant difference was found in left long shoulder height (p = 0.03), right and left armscye girth (p = 0.03 and p = 0.04), left and right knee height (p = 0.02 and p = 0.01), right and left length straight (both p = 0.00), right and left upper arm girth (both p = 0.00), right and left elbow girth (both p=0,.00), right and left forearm girth (p = 0.00 and p = 0.01), left wrist girth (p = 0.02), right and left knee girth (both p = 0.00) and in right and left calf girth (p = 0.01 and p = 0.00). A tendency of p = 0.05 was found between 2015 and 2016 right wrist girth measurement (Table 3 and 4).

**Table 1.** Changes in basic anthropometric indicators after the annual training cycle (2015-2016) of 7 young judokas (between 15 and 16 years old).

| Variable | Age (years) | Mean | SD | Difference |
|---|---|---|---|---|
| Body height (cm) | 15 | 171.01 | 9.69 | 5.50* |
| | 16 | 176.51 | 9.71 | |
| Body weight (kg) | 15 | 62.99 | 8.97 | 9.03* |
| | 16 | 72.01 | 7.25 | |
| Skeletal muscle mass (kg) | 15 | 31.59 | 5.87 | 4.23* |
| | 16 | 35.83 | 5.44 | |
| Body fat mass (kg) | 15 | 6.69 | 2.87 | 1.74 |
| | 16 | 8.43 | 4.26 | |
| % of body fat mass | 15 | 10.79 | 4.56 | 1.05 |
| | 16 | 11.84 | 6.05 | |
| Lean body mass (kg) | 15 | 24.52 | 4.45 | 3.68* |
| | 16 | 28.20 | 4.34 | |

*p<0.05

**Table 2.** Differences between right (R) and left (L) selected morphological variables after the annual training cycle (2015-2016) of 7 young judokas (between 15 and 16 years old).

| Variable (cm) | Side | 2015 | | | | 2016 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | t | p | Mean | SD | t | p |
| Long shoulder height | R | 141.11 | 9.24 | 1.00 | 0.36 | 143.90 | 8.69 | 0.32 | 0.76 |
| | L | 140.11 | 6.85 | | | 143.69 | 7.28 | | |
| Arm length straight | R | 55.77 | 4.47 | 1.02 | 0.35 | 58.83 | 5.10 | 1.28 | 0.25 |
| | L | 55.23 | 4.17 | | | 57.91 | 3.42 | | |
| Armscye girth | R | 41.30 | 4.14 | –0.43 | 0.68 | 43.80 | 2.49 | –0.88 | 0.42 |
| | L | 41.74 | 4.33 | | | 44.33 | 2.31 | | |
| Upper arm girth | R | 28.54 | 2.33 | –1.96 | 0.10 | 31.53 | 2.75 | 0.11 | 0.92 |
| | L | 29.03 | 1.99 | | | 31.50 | 2.70 | | |
| Elbow girth | R | 25.74 | 1.81 | 1.32 | 0.24 | **27.41** | 1.70 | 2.76 | **0.03** |
| | L | 25.24 | 1.70 | | | 26.44 | 1.70 | | |
| Forearm girth | R | **25.97** | 1.97 | 3.41 | **0.01** | **27.60** | 1.80 | 3.05 | **0.02** |
| | L | 25.33 | 2.28 | | | 26.87 | 1.75 | | |
| Wrist girth | R | 17.13 | 1.12 | 0.04 | 0.97 | 17.80 | 0.98 | –0.61 | 0.57 |
| | L | 17.11 | 1.38 | | | 17.94 | 1.19 | | |
| Side waist 2 floor | R | 102.11 | 6.10 | –1.63 | 0.25 | 103.44 | 7.83 | 0 | 1.00 |
| | L | 102.01 | 6.06 | | | 103.44 | 7.83 | | |
| Outside leg length | R | 102.83 | 6.01 | 1.00 | 0.36 | 104.26 | 7.93 | –0.68 | 0.52 |
| | L | 102.79 | 6.04 | | | 104.29 | 7.92 | | |
| Thigh girth | R | 58.23 | 9.03 | 1.78 | 0.13 | 56.43 | 3.38 | 1.19 | 0.28 |
| | L | 57.53 | 8.76 | | | 55.97 | 3.05 | | |
| Thigh length | R | 33.19 | 4.70 | 0.29 | 0.78 | 31.61 | 4.23 | 1.31 | 0.24 |
| | L | 33.14 | 4.99 | | | 31.47 | 4.20 | | |
| Mid thigh girth | R | **47.54** | 4.06 | 3.26 | **0.02** | 48.53 | 2.74 | –1.86 | 0.06 |
| | L | 46.36 | 3.81 | | | 47.91 | 2.56 | | |
| Mid thigh height | R | 65.00 | 4.05 | –1.00 | 0.32 | 65.20 | 5.30 | –1.00 | 0.32 |
| | L | 65.03 | 4.08 | | | 65.21 | 5.32 | | |
| Knee girth | R | 37.06 | 1.56 | 2.32 | 0.06 | 38.63 | 1.06 | 2.37 | 0.06 |
| | L | 36.49 | 1.39 | | | 38.34 | 0.94 | | |
| Knee height | R | 48.81 | 3.26 | –1.00 | 0.32 | 49.43 | 3.29 | –1.34 | 0.18 |
| | L | 48.86 | 3.31 | | | 49.47 | 3.34 | | |
| Calf girth | R | **35.30** | 1.99 | 2.73 | **0.03** | 36.90 | 2.02 | 1.64 | 0.15 |
| | L | 34.63 | 1.70 | | | 36.46 | 1.65 | | |
| Calf height | R | 37.33 | 5.22 | 1.08 | 0.36 | 37.23 | 4.05 | –1.17 | 0.24 |
| | L | 36.19 | 4.13 | | | 36.14 | 3.06 | | |

**Table 3.** Differences between 15 and 16 years old of young judokas (n = 7) measurement for upper body symmetries for both sides.

| Variable (cm) | Age (years) | Mean | SD | t | p |
|---|---|---|---|---|---|
| Right arm length straight | 15 | 55.77 | 4.47 | –5.74 | **0.00** |
| | 16 | **58.83** | 5.10 | | |
| Left arm length straight | 15 | 55.23 | 4.17 | –4.60 | **0.00** |
| | 16 | **57.91** | 3.42 | | |
| R long shoulder height | 15 | 141.11 | 9.24 | –1.84 | 0.12 |
| | 16 | 143.90 | 8.69 | | |
| L long shoulder height | 15 | 140.11 | 6.85 | –2.92 | **0.03** |
| | 16 | **143.69** | 7.28 | | |
| Right armscye girth | 15 | 41.30 | 4.14 | –2.84 | **0.03** |
| | 16 | **43.80** | 2.49 | | |
| Left armscye girth | 15 | 41.74 | 4.33 | –2.58 | **0.04** |
| | 16 | **44.33** | 2.31 | | |
| Right upper arm girth | 15 | 28.54 | 2.33 | –6.14 | **0.00** |
| | 16 | **31.53** | 2.75 | | |
| Left upper arm girth | 15 | 29.03 | 1.99 | –4.85 | **0.00** |
| | 16 | **31.50** | 2.70 | | |
| Right elbow girth | 15 | 25.74 | 1.81 | –6.60 | **0.00** |
| | 16 | **27.41** | 1.70 | | |
| Left elbow girth | 15 | 25.24 | 1.70 | –4.86 | **0.00** |
| | 16 | **26.44** | 1.70 | | |
| Right forearm girth | 15 | 25.97 | 1.97 | –10.38 | **0.00** |
| | 16 | **27.60** | 1.80 | | |
| Left forearm girth | 15 | 25.33 | 2.28 | –3.82 | **0.01** |
| | 16 | **26.87** | 1.75 | | |
| Right wrist girth | 15 | 17.13 | 1.12 | –2.50 | **0.05** |
| | 16 | **17.80** | 0.98 | | |
| Left wrist girth | 15 | 17.11 | 1.38 | –3.17 | **0.02** |
| | 16 | **17.94** | 1.19 | | |
| Right side waist 2 floor | 15 | 102.11 | 6.10 | –1.41 | 0.21 |
| | 16 | 103.44 | 7.83 | | |
| Left side waist 2 floor | 15 | 102.01 | 6.06 | –1.48 | 0.19 |
| | 16 | 103.44 | 7.83 | | |

**Table 4.** Differences between 15 and 16 years old of young judokas (n = 7) measurement for lower body symmetries for both sides.

| Variable (cm) | Age (years) | Mean | SD | t | p |
|---|---|---|---|---|---|
| Right outside leg length | 15 | 102.83 | 6.01 | –1.42 | 0.21 |
| | 16 | 104.26 | 7.93 | | |
| Left outside leg length | 15 | 102.79 | 6.04 | –1.53 | 0.18 |
| | 16 | 104.29 | 7.92 | | |
| Right thigh girth | 15 | 58.23 | 9.03 | 0.66 | 0.53 |
| | 16 | 56.43 | 3.38 | | |
| Left thigh girth | 15 | 57.53 | 8.76 | 0.60 | 0.57 |
| | 16 | 55.97 | 3.05 | | |
| Right thigh length | 15 | 33.19 | 4.70 | 0.65 | 0.54 |
| | 16 | 31.61 | 4.23 | | |
| Left thigh length | 15 | 33.14 | 4.99 | 0.68 | 0.53 |
| | 16 | 31.47 | 4.20 | | |
| Right mid thigh girth | 15 | 47.54 | 4.06 | –1.12 | 0.31 |
| | 16 | 48.53 | 2.74 | | |
| Left mid thigh girth | 15 | 46.36 | 3.81 | –1.81 | 0.12 |
| | 16 | 47.91 | 2.56 | | |
| Right mid thigh height | 15 | 65.00 | 4.05 | –0.16 | 0.88 |
| | 16 | 65.20 | 5.30 | | |
| Left mid thigh height | 15 | 65.03 | 4.08 | –0.15 | 0.89 |
| | 16 | 65.21 | 5.32 | | |
| Right knee height | 15 | 48.81 | 3.26 | –3.22 | **0.02** |
| | 16 | **49.43** | 3.29 | | |
| Left knee height | 15 | 48.86 | 3.31 | –3.40 | **0.01** |
| | 16 | **49.47** | 3.34 | | |
| Right knee girth | 15 | 37.06 | 1.56 | –6.23 | **0.00** |
| | 16 | **38.63** | 1.06 | | |
| Left knee girth | 15 | 36.49 | 1.39 | –5.24 | **0.00** |
| | 16 | **38.34** | 0.94 | | |
| Right calf height | 15 | 37.33 | 5.22 | 0.11 | 0.91 |
| | 16 | 37.23 | 4.05 | | |
| Left calf height | 15 | 36.19 | 4.13 | 0.05 | 0.97 |
| | 16 | 36.14 | 3.06 | | |
| Right calf girth | 15 | 35.30 | 1.99 | –4.26 | **0.01** |
| | 16 | **36.90** | 2.02 | | |
| Left calf girth | 15 | 34.63 | 1.70 | –5.11 | **0.00** |
| | 16 | **36.46** | 1.65 | | |

## DISCUSSION

Statistical significant differences between sides in 2015 and 2016 were observed in 3 variables in 2015 alongside 2 variables in 2016. In 2015 the statistically significant differences were observed in mid-thigh girt, calf girth and forearm girth. All of the variables were greater on the dominant (right) side of judokas. Two of the variables were found on lower body extremities. This could be explained on behalf of the usage of *tokui-waza* (special techniques) which was in most of the participants from leg techniques. Because, the usage of the dominant right leg, which can be categorised as an attacking leg, was more frequent. Therefore, the execution leg is getting much more concentric and eccentric work than the supporting leg which could lead to imbalances between muscle groups [24].

On behalf of those findings the training process for the 2016 was adapted to lower the possibility of the occurrence of injuries in lower body extremities, consequentially to lower the differences between left and right leg statistically significant variables. Also the training process in 2016 was more focused in developing better *kumi kata* (grip fighting). We are always looking towards to the equally good performance of youth judokas in both left and right fighting stances. Although, the judokas are always in a certain way relaying more on the dominant right hand, which can be supported with statistically greater differences found in 2016 on variables elbow girth and forearm girth.

Only one statistical significant difference (forearm girth) has occurred in 2015 and 2016 ($p = 0.01$ in 2015 and $p = 0.02$ in 2016). Similar results were obtained in one of our prior studies made on older judokas (21 ±3.5 years old) [17]. We suggest that the main reason for this difference is simple right hand dominance which in right dominant fighting stance first grabs the opponent the kimono's lapel to start the attack [17]. Similar results were obtained in studies on top level gymnasts [25] and in youth tennis players [26]. Forearm girth differences in two straight measurements can in future results in higher incidence of injury due to increasingly higher ratios of injuries/ years of exposure in older judokas categories (above 15 years old) [27].

Between 2015 and 2016 measurements we found statistical significance in almost all of the upper body variables and in 3 variables for lower limbs on both sides. The main reason for this could be end of the peak height velocity phase, which induces muscle and bones growth of upper and lower limbs [28]. In our study the increase in body height was also accompanied by increase in weight similarly to the study made on 33 Flemish male youth soccer players from the Ghent Youth Soccer Project [13]. They also reported that physical performance showed peak development at peak height velocity [13]. Also as previously mentioned the training process in the 2016 was more focused on grip fighting which involves more intensively the upper body muscles.

## CONCLUSIONS

From the study we can see that in a one years of intense training the youth body can be influenced in different ways. With the help of the modern technology and sports testing we can use the acquired data and guide the training process in the way that can lower the occurrence of injuries but still develop the aimed goals, which are connected with better agility, power and better technique. But if the data are ignored we can see that in one year the body develops enormously and also some body asymmetries start to occur. If that kind of training process continues in further years, the judokas dominant fighting stance would become superior in younger age categories, which could possibly bring some podium results but for the long run the occurrence of injuries is imminent and maybe even a drop out of judo is very likely to follow. Therefore, the usage of sports testing and especially the useful interpretation of data is necessary in combination with additional education of judo coaches.

## CONFLICTS OF INTEREST

The authors of this study declare that they have no conflicts of interest.

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