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# Differences in anthropometric, motoric and cognitive abilities between athletically trained and untrained girls

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## Summary

*Study aim*: the aim of the study was to identify differences between athletically trained and untrained subjects with respect to body composition, motor and cognitive abilities.

*Materials and methods*: three groups of girls aged 12 to 14 years old participated in the study: young judokas (n = 42), volleyball players (n = 54) and their untrained peers (n = 54). Variables of interest were assessed through eight motor tests, nine anthropometric variables and the RSPM.

*Results*: this study showed differences in some anthropometric characteristics and almost all motoric abilities between trained girls and untrained girls ($p < 0.05$), indicating that well-programmed activity can positively influence these characteristics and abilities. In addition, group of volleyball players presented significantly better results in cognitive abilities ($p < 0.01$), indicating a need for intelligence in complex sports like volleyball.

*Conclusions*: generally, the trained groups of athletes possessed better coordination and strength than their untrained counterparts.

**Key words: The Raven's Standard Progressive Matrices – Judo – Volleyball – Training – Intelligence**

## Introduction

Judo and volleyball are high-intensity activities; judokas try to throw opponents onto their backs or control them while fighting on the floor [9, 18]; volleyball players try to serve and accept serve as well as to spike for gaining points [20]. For these reasons, both judokas and volleyball players are required to be in excellent physical condition [9, 18] in order to perform well. Judo fights last for five minutes of active time, or up to nine minutes including breaks. A volleyball match consists of three or five sets, with a three-minute break between sets. These kinds of activities are predominantly anaerobic [4], consisting of repeated segments of active motion and rest [13, 16].

The analysis of morphological variables and types of children and youths, athletes and non-athletes alike, involves age-dependent changes throughout the growth period [2]. This raises issues such as dieting, the role of physical activity and factors affecting growth and development [10, 14]. Whereas, under extreme conditions, sport training may affect the longitudinal and/or transversal dimensions of the skeleton [2], judo and volleyball training aim to optimize muscle structure and subcutaneous fat tissue [1]. Previous research has confirmed significant differences between athletes and non-athletes with respect to subcutaneous fat and relative lean body mass. These differences may partly result from the selection and adaptation of body components to prolonged training, leading to the development of specific constitutional or morphological characteristics of young athletes [6].

Motor and cognitive abilities are of great importance for success in judo and volleyball. Therefore, full attention should be paid to shaping these abilities from the very beginning of training. It ought to be remembered that environmental factors, including carefully planned and programmed training methods, can contribute to shaping motor and cognitive abilities together with genetic predispositions. According to the requirements of long-term planning and programming, the proportions and relations of certain elements of sport preparation vary at different stages [2].

The aim of this study was to assess the differences between trained judokas, volleyball players and untrained children in their cognitive, motor and anthropometric

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characteristics. Considering that judo matches and volleyball games are interval activities consisting of maximal (explosive) effort interrupted by short breaks [13, 16], the authors assumed strength and power to be relevant determinants for success in these activities. On the other hand, the complexity of combat and the game structure, as well as a large number of techniques used during the fight or game, may suggest that cognitive abilities and coordination also represent key determinants for success in these sports, as has been previously suggested [5, 12, 19]. Such a defined structure of cognitive and motor abilities in sport could be valuable both from a scientific and a practical point of view.

## Materials and methods

### The sample of subjects

The sample of subjects was drawn randomly from a number of elementary schools in Vojvodina (Serbia), consisting of 150 children aged between 12 and 14 years old (42 judokas, 54 volleyball players and 54 untrained children). All of the subjects and their parents were fully informed about the nature and demands of the study and all parents voluntarily gave their informed consent for their child to participate in the study. The University's Ethical Advisory Commission approved the study in accordance with the Helsinki Declaration. All measurements and tests were carried out in the morning (from 8:00 to 12:00) by measurers who used the same measuring instruments and protocols and who were trained in the same manner.

### Measurements and tests

All measurements were conducted according to the International Biological Programme. For assessing anthropometry, body height, body mass, chest girth, abdominal girth, mid-arm girth, forearm girth, abdominal, subscapular and triceps skin-folds were taken. Motor fitness variables were assessed using the following tests: a backwards obstacle course and slalom with three balls (functional coordination), plate tapping (speed of hand movement), sit-and-reach (flexibility), standing broad jump and 20-m dash (explosive strength), bent-arm hang (isometric muscular endurance) and sit-ups with crossed arms (isotonic muscular endurance). Short descriptions of the tests are given below. This set of eight motor tests assessed the following functional mechanisms: movement structuring, tonus and synergetic regulation, regulation of excitation intensity and regulation of excitation duration [21, 22].

Every subject performed a trial test in order to become familiarized with the protocol; after that, the results were recorded.

*Backwards obstacle course*: the subject walks backwards on all fours for a distance of 10 m, climbs the top of a Swedish bench and goes through the frame of the bench. Time is measured in 0.1-s units.

*Slalom with three balls*: on the command 'GO', the subject rolls three balls between cones at a distance of 10 m. After having passed the last of the five cones, the subject rounds it and continues rolling all three balls toward the starting line. Time is measured in 0.1-s units.

*Arm plate tapping*: the subject alternately taps two plates on a tapping board with his dominant hand, holding the other hand between plates for 15 s. The number of double taps is recorded.

*Standing broad jump*: the subject jumps with both feet from the reversed side of a Reuter's bounce board onto a carpet with a scale. The jumping distance is recorded in centimetres.

*20-m dash*: on the command 'GO', the subject runs 20 m at the highest speed possible. The subjects run in pairs. Time is measured in 0.1-s units.

*Sit-ups with crossed arms*: the subject lies on the back with knees bent and arms crossed over the chest and perform sit-ups with his or her feet being held tightly by an assistant. The number of correctly executed sit-ups in 60 s is recorded.

*Bent-arm hang*: the subject grips the bar with fingers on top and the thumb underneath, pulls up (chin above the bar) and holds the position as long as possible without resting the chin on the bar. Time is measured in 0.1 sec units.

These tests were supposed to reflect motor functions and were considered the primary latent motor factors. This approach allowed for a decrease in the number of motor tests performed in order to improve the motivation of the schoolchildren [24].

The Raven's Standard Progressive Matrices (RSPM) assessed cognitive abilities (for abstract reasoning) [23]. RSPM are multiple choice tests in which a candidate is asked to identify the missing segment required to complete a larger pattern in each test item. Many items are presented in the form of a 3 × 3 or 2 × 2 matrix, giving the test its name. There are five sets (A to E) of 12 item each (e.g. A 1 through A 12); items within a set become increasingly difficult, requiring even greater cognitive capacity to encode and analyse information.

### Data analysis

In order to check for differences between groups, all data were subjected to one-way ANOVA with post-hoc Newmann-Keuls's test; the level of $p \leq 0.05$ was considered significant. All data are presented as mean and standard deviation. Statistical analyses were performed with the use of SPSS 20 (SPSS ID: 729225) software.

## Results

Mean values (±SD) of basic variables are presented in Table 1. One-way ANOVA revealed significant differences between judokas, volleyball players and untrained girls in almost all motoric tests, the cognitive test and in the majority of anthropometric variables.

The mean values of basic anthropometric characteristics for trained girls from 12 to 14 years of age (body height, chest girth, mid-arm girth, forearm girth and abdominal girth) differed significantly ($p < 0.01$) from the untrained girls, whereas no significant differences were found in skin fold measurements between groups.

In addition, the trained group of girls significantly differed from the untrained girls in the results of the following motor tests: 20-m dash, arm plate tapping, forward bend and crossed-arm sit-ups ($p < 0.01$). Differences in the results of the backwards obstacle course, slalom with three balls and standing broad jump were less profound ($p < 0.05$). Furthermore, significant differences were found in Raven's standard progressive matrix in favour of the volleyball group compared to the judo and untrained groups (Table 1).

## Discussion

The cross-sectional study presented here shows significant differences of anthropometric characteristics in both of the trained groups versus the untrained group (all girth values and body height), functional coordination (backwards obstacle course and slalom with three balls), speed of hand movement (arm plate tapping), explosive strength (standing broad jump and 20-m dash), muscle endurance (sit-ups) and cognitive abilities. The trained groups generally performed better in almost all motoric tests and in the cognitive test.

Anthropometric variables can make different contributions to the morphological structure of the body at different periods of development. In addition to biological growth and development, a child's body can be significantly affected by proper high-intensity training [2, 25]. In our study, body heights for members of the volleyball

**Table 1.** Descriptive statistics for girls

| Variable | Judo-trained (N = 42) | Volleyball-trained (N = 54) | Untrained (N = 54) | F | p |
|---|---|---|---|---|---|
| | M ± SD | M ± SD | M ± SD | | |
| Age | 13.00 ± 0.91 | 13.16 ± 0.37 | 13.00 ± 0.54 | 1.092 | 0.338 |
| Body height (cm) | 156.96 ± 6.45 | 166.41 ± 6.69‡,** | 159.49 ± 11.16 | 16.373 | 0.000 |
| Body weight (kg) | 50.54 ± 10.58 | 54.24 ± 9.79 | 57.63 ± 6.54 | 0.370 | 0.691 |
| Chest girth (cm) | 78.17 ± 6.46** | 78.82 ± 6.07** | 73.77 ± 9.83 | 6.634 | 0.002 |
| Abdominal girth (cm) | 69.77 ± 7.81 | 72.44 ± 7.11** | 67.56 ± 8.57 | 5.222 | 0.006 |
| Mid-arm girth (cm) | 23.99 ± 2.76 | 23.86 ± 2.29** | 22.21 ± 2.60 | 7.904 | 0.001 |
| Forearm girth (cm) | 21.60 ± 1.78** | 22.21 ± 1.74** | 20.91 ± 2.10 | 5.600 | 0.005 |
| Abdominal skinfold (mm) | 14.83 ± 6.59 | 15.77 ± 6.38 | 14.40 ± 7.69 | 0.550 | 0.578 |
| Subscapular skinfold (mm) | 9.54 ± 4.29 | 9.09 ± 3.51 | 9.46 ± 4.67 | 0.167 | 0.847 |
| Triceps skinfold (mm) | 10.96 ± 3.25 | 12.03 ± 3.81 | 12.12 ± 5.29 | 1.037 | 0.357 |
| 20-m dash (s) | 4.11 ± 0.27** | 4.19 ± 0.24** | 4.39 ± 0.37 | 11.854 | 0.000 |
| Backwards obstacle course (s) | 12.48 ± 2.35†,* | 15.21 ± 3.70* | 18.06 ± 4.98 | 23.921 | 0.000 |
| Slalom with three balls (s) | 35.80 ± 5.48††,* | 40.16 ± 7.94 | 38.81 ± 9.07 | 3.779 | 0.025 |
| Arm plate tapping (freq.) | 31.45 ± 3,81†,* | 33.33 ± 4.03** | 29.24 ± 3.56 | 15.632 | 0.000 |
| Forward bend (cm) | 54.31 ± 11,45 | 68.39 ± 9.11‡,** | 53.39 ± 11.93 | 31.341 | 0.000 |
| Standing broad jump (cm) | 177.00 ± 17,53* | 177.80 ± 16.56* | 166.96 ± 26.89 | 4.284 | 0.016 |
| Bent-arm hang (s) | 31.43 ± 20.65 | 33.74 ± 20.37 | 26.69 ± 18.55 | 1.764 | 0.175 |
| Crossed-arm sit-ups (freq.) | 46.60 ± 7.89††,** | 40.13 ± 6.32* | 36.74 ± 9.67 | 17.738 | 0.000 |
| Raven's standard progressive matrix (points) | 43.45 ± 7.64 | 48.19 ± 5.95‡,* | 44.81 ± 7.85 | 5.730 | 0.004 |

Better than judo group ‡ 0.01; better than volleyball group †† 0.01, † 0.05; better than untrained group ** 0.01, * 0.05

group were above average for the participants' age. This finding corroborates some previous studies [11, 15] indicating sport-specific characteristics for pre-selection in volleyball. Furthermore, better results in girths compared to the untrained group could be attributed to the effects of judo and volleyball training.

Given the structure of activity in judo and volleyball, both motor and cognitive abilities are of great importance for success [6], and functional coordination has been highly ranked among the desired motor abilities. The complexity of motion structures in judo and volleyball is manifested by a high number of techniques that may contribute to success only if they are applied in a timely fashion and in accordance with the principles of these sports. By continuously modifying dynamic situations during a fight or game, athletes of both sports are required to accept the applied technical-tactical stereotypes, demonstrate the ability to instantly recognize these stereotypes and create new plans of defence, attack and counterattack actions [7]. This set of coordination abilities is formed rather early, especially rhythmic coordination, including agility, rhythm, and motor responses [6]. The significant differences that were found in the observed motoric variables are affirmative to applied training processes and exercise. They confirm that it is never too early to develop coordination because it is a prerequisite to learn better motor coordination during later stages of athletic training [2].

In addition, the dominance of explosive leg strength and speed of hand movement for both judokas and volleyball players can be expected, considering the fact that explosive movements dominate both in judo matches and in volleyball games. These abilities are presented with fast handgrips and ball bouncing followed by fast movements in all directions, along with speed and motion accuracy in order to timely react to actions of defence and attack [17]. Additionally, the judo group showed significantly better results in muscle endurance compared to both the volleyball and untrained groups, demonstrating substantially greater abdominal endurance. This corroborates with previous studies [3, 7, 8] that have shown that strength and endurance play an important role for success in sport.

The results of cognitive abilities show that the volleyball group performed significantly better than the untrained group and the judo group. It has been postulated that the more complex a sport structure is, the more relevant an athlete's cognitive abilities are for success in that sport [6, 27, 28]. The results of RSPM in the judo group were not as significantly different to those of the untrained group as was expected. In addition, this is not in line with a previous study [6] that demonstrated that cognitive abilities may be more of a factor in judo for girls than boys. These discrepancies could be due to the shorter training experience in girls that practice judo. The volleyball group's better results could be explained by the fact that long-term training combined with frequent stressful situations associated with problem solving during a competition contributes to building a relatively specific cognitive functioning [6]. On the other hand, it could be suggested that intelligence could influence sport selection, and vice versa.

## Conclusion

In conclusion, this study shows differences in some anthropometric characteristics and almost all motoric abilities between athletically trained girls and untrained ones, with the trained groups' higher values indicating that well-programmed activity can positively influence these characteristics and abilities. The girls who participated in volleyball also had significantly better cognitive abilities, indicating a need for intelligence in complex sports like volleyball. Generally, the trained athletes possessed better coordination and strength than their untrained counterparts.

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