Anthropometric Characteristics and Agility of Wheelchair Basketball Players : Differences and Relationship with Functional Classification

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ANTROPOMETRIJSKE KARAKTERISTIKE I AGILNOST KOŠARKAŠA U INVALIDSKIM KOLICIMA: RAZLIKE I POVEZANOST SA FUNKCIONALNOM KLASIFIKACIJOM

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SUMMARY

The aim of this study was to determine: (1) differences in anthropometric characteristics and agility between different functional classes of wheelchair basketball players and (2) the relationship between anthropometric characteristics and agility with the functional classification of wheelchair basketball players. The sample of participants consisted of 40 wheelchair basketball players, aged 33.9 ± 11.2 years. Anthropometric characteristics (longitudinal and circular dimensions, as well as skinfold thickness) were assessed, and agility was measured using the modified T-test and Figure-of-Eight test. The results of the one-way analysis of variance showed significant differences with very large effects between players of different functional classes in body mass, sitting height, and sitting reach height, while significant differences with large effects were recorded in the agility assessment tests: the T-test and the Figure-of-Eight test. Also, the results of the correlation analysis indicate that there are significant moderate positive correlations of sitting height and reaching height with functional classification.

Key words: *disability, t-test, sports, motor skills, athletes*

INTRODUCTION

Wheelchair basketball (WB) is one of the most popular adapted sports for people with disabilities. According to estimates by the International Wheelchair Basketball Federation (IWBF), this sport is practiced by more than 100,000 players from 95 countries around the world (IWBF, 2021). Wheelchair basketball is a dynamic, high-intensity activity that requires a large number of skills for wheelchair maneuvering (e.g., propulsion, acceleration, stopping and changing the direction of the wheelchair) and ball handling (e.g., shooting, passing, dribbling, etc.).

The official rules of the WB game are to a large extent identified with the rules in classic basketball, but they are also specific in part, i.e. adapted to athletes with disabilities. Given the presence of participants with various impairments and the use of wheelchairs in the game, the IWBF has developed a classification system in order to balance the wide variety of functional abilities of players between teams and to ensure that all eligible players have an equal right and opportunity to play. The classification system implies a process by which the total score of the team's potential is matched with the team's potential of the opponent (Kozomora et al., 2019). Based on the functional ability of the players, the classification is done by scoring in the range of 1.0 to 4.5 points, so that the total score of one team does not exceed the limit of 14 points (IWBF, 2018). A Class 1 player has no or very poor trunk control in any plane. A Class 2 player has active rotation of the upper trunk, which allows partial range of motion in the transverse and sagittal planes. A Class 3 player has full range of motion in the transverse and sagittal planes but lacks full action in the frontal plane. A Class 4 player has full range of motion in the transverse and sagittal planes and full range of motion to one side in the frontal plane, while a Class 4.5 player has full control of motion in all planes.

For success in wheelchair basketball, it is very important that players possess strong basic wheelchair ability, such as agility. It is also recommended that wheelchair basketball players focus on achieving maximum agility because if a player cannot move their wheelchair efficiently around the basketball court and change direction quickly, it does not matter how well they perform other skills of the game (Frogley, 2010). Agility and the ability to repeat sprints and change direction are considered very important wheelchair basketball performances (Iturricastillo, 2021). There are factors that can influence agility in wheelchair basketball players, such as anthropometric characteristics, upper body strength, and wheelchair propulsion technique (Vanlandewijck et al., 2001; Rice et al., 2011). In wheelchair basketball, the analysis of anthropometric measures and complete body composition is very important. It can help trainers choose key anthropometric measures to use during training in order to increase the success rate (Cavedon et al., 2018). Davis (1993) investigated the motor efficiency of the upper limbs and emphasized that the distribution of muscle mass and anthropometric measures of the upper limbs and trunk, which is the center of gravity when sitting in a wheelchair, are very important for the successful performance of a motor task. Speed may also affect agility, given that some performance tests are related to speed (Vanlandewijck et al., 1999; de Groot et al., 2012). However, it is still not fully clarified how and to what extent agility is manifested in relation to the functional classification of players or whether certain anthropometric characteristics contribute to the manifestation of agility. It is considered that the assessment of the level of ability of wheelchair basketball players in relation to the functional classification is an important part that should be further investigated in order to provide the possibility of more equal competition (Brasile, 1990). Given the insufficient number of studies on this topic, the aim of this study is to determine: (1) differences in anthropometric characteristics and agility between different functional classes of wheelchair basketball players and (2) the relationship between anthropometric characteristics and agility with the functional classification of wheelchair basketball players**.**

METHODS

A sample of participants

The sample of participants for this study consisted of 40 male wheelchair basketball players (Table 1) from clubs in the Balcan region: KKK "Nais" from Niš, KKK "Bijeljina" from Bijeljina, KKK "Zmaj" from Gradačac, SSOSIK from Kruševac, as well as national team members from Serbia, Montenegro and Bulgaria. Testing protocol was conducted during tournaments in Bijeljina and Bojnik. Only players who voluntarily agreed to participate in the testing protocol were included. This study was conducted in accordance with the Declaration of Helsinki of the World Medical Association (World Medical Association, 2013). The privacy of the players was protected by the fact that the data was used only for the purposes of the study and was not available to third parties. For comparative analysis, the total sample was divided into four classes in relation to the official IWBF scoring of the functional classification. Class 1 (n = 10) consisted of players with scores of 1.0 and 1.5, Class 2 (n = 13) players with scores of 2.0 and 2.5, Class 3 (n = 7) players with scores of 3.0 and 3.5 and Class 4 (n = 10) players with points 4.0 and 4.5.

Table 1. *Basic characteristics of the sample*

	N	**Mean ± SD or %**
Age (years)	40	33.9 ± 11.2
Sitting Height (cm)	40	93.4 ± 6.7
Body Mass (kg)	40	78.7 ± 17.8
IWBF classification		
Class 1 (classes 1.0 and 1.5)	10	25.0%
Class 2 (classes 2.0 and 2.5)	13	32.5%
Class 3 (classes 3.0 and 3.5)	7	17.5%
Class 4 (classes 4.0 and 4.5)	10	25.0%

IWBF – International Whellchair Basketball Federation;
Mean - average value; SD – standard deviation.

Instruments and procedures

Measuring instruments for assessing the anthropometric characteristics of the sample:

• Sitting height (cm)
• Seated reach height (cm)
• Arm span (cm)
• Forearm circumference (cm)
• Upper arm circumference (cm)
• Forearm skinfold thickness (mm)
• Biceps skinfold thickness (mm)
• Triceps skinfold thickness (mm)
• Suprailiac skinfold thickness (mm)
• Subscapular skinfold (mm)

Measuring instruments for the assessment of sample agility

• Modified T-test (sec)

• Modified Figure-of-Eight test (number of laps)

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Anthropometric characteristics

An anthropometer according to Martin GPM 101 (GPM Switzerland) with a precision of 0.1 cm was used to assess longitudinal dimensions (sitting height, sitting reach height, and arm span). A centimeter tape with a precision of 0.1 cm was used to assess the circular dimensions (forearm circumference and upper arm circumference). A GPM (GPM Switzerland) caliper with a measurement accuracy of 0.2 mm was used to assess forearm, biceps, triceps, suprailiac, and subscapular skinfold thicknesses.

Modified T-test

The T-test was carried out in accordance with a modified testing protocol for wheelchair basketball players (Yanci et al., 2015), in which the wheelchair was only moved forward during the test. The participant is positioned 0.5 m behind cone "A", in whose extension the starting line is drawn. The distance between A and B is 9.14 m. When participant is ready, he/her pushes the wheelchair forward as fast as possible to cone B. The subject then moves towards cones "C" "D", and "B" (in order) touching the top of each cone, and finally returns (moving forward) to cone "A" (Figure 1). For accurate time measurement, Witty photocells (Microgate, Italy) were used. The subject performed the test twice, and the best result in seconds was recorded.

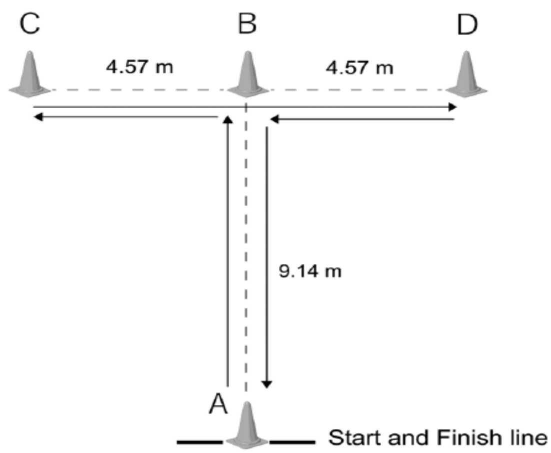

Figure 1. *Sketch of the T-test (Tachibana et al., 2019)*

Modified Figure-of-Eight test

The protocol for performing the Figure-of-Eight test is provided by Vanlandewijck, Daly, and Theisen (1999). After the signal, the participant pushes the wheelchair around two cones in a figure-of-eight path, as fast as possible. The cones are placed 5 m apart (Figure 2). Scoring was recorded as the maximum number of laps that the subject completed in 1 minute.

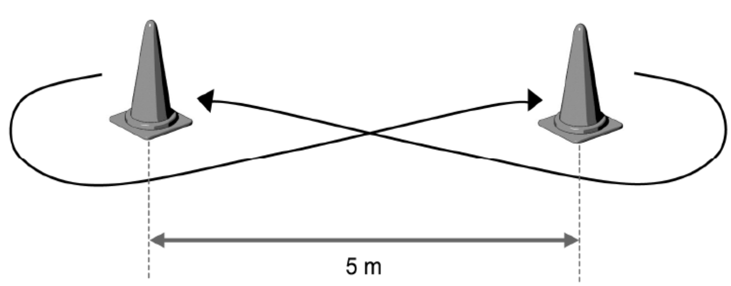

Figure 2. *Sketch of the Figure-of-Eight test (Tachibana et al., 2019)*

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Statistical analysis

Data processing and analysis was performed with the statistical package IBM SPSS v.23. Descriptive parameters were calculated for all variables included in this study. The assumption of a normal distribution of the monitored variables was checked with the Shapiro-Wilk test. To determine the differences in anthropometric characteristics and agility in relation to the functional classes of players, a one-way analysis of variance (One-way ANOVA) was applied for variables with normal distribution, while in the case of variables that do not meet the assumption of a normal distribution, the Kruskal-Wallis test for independent samples was applied. For further analysis of statistically significant differences between groups, the Bonferroni post hoc test was applied.

The significance of the differences is presented using the Effect Size based on the following criteria: < 0.20 trivial; 0.20-0.50 small; 0.50-0.80 moderate; 0.80-1.3 large and > 1.3 very large (Cohen, 1988). Spearman's rho correlation analysis was used to determine the relationship between anthropometric characteristics, agility and functional classification of players. Statistical significance was set at the $p < 0.05$ level.

RESULTS

Demographic data, anthropometric characteristics and agility according to the functional classification of the players are shown in Table 2. The results of the Shapiro-Wilk test for checking the normality assumption showed normal distributions for all variables except for the Figure-of-Eight test where deviations from the normal distribution were observed. The significance of differences in demographic characteristics, anthropometric characteristics and agility in relation to functional classification can be seen in Table 2. The results of one-way analysis of variance showed significant differences with very large effects between players of different functional classes in body mass, sitting height and sitting reach height ($p = 0.005$, $d = 1.31$; $p = 0.005$, $d = 1.31$; $p = 0.001$, $d = 1.46$, respectively), while significant differences with large effects were noted in the agility tests, T-test and Figure-of-Eight test ($p = 0.046$; $d = 1.03$; $p = 0.026$, $d = 0.90$, respectively).

Table 1. *Demographics, Anthropometric characteristics and agility according to functional classification*

Variable	Class 1 (n = 10)	Class 2 (n = 13)	Class 3 (n = 7)	Class 4 (n=10)	p	ES
Age (years)	34.0 ± 9.2	32.3 ± 12.1	31.7 ± 12.0	37.5 ± 12.2	.686	0.41
body mass (kg)	83.4 ± 19.2	69.4 ± 13.8	70.1 ± 10.2	92.3 ± 16.4	**.005***	1.31
Sitting height (cm)	91.0 ± 8.7	90.5 ± 5.1	93.4 ± 2.5	99.4 ± 4.7	**.005***	1.31
Seated reach height (cm)	142.4 ± 9.2	142.2 ± 8.1	143.7 ± 3.3	154.5 ± 6.3	**.001***	1.46
Arm span (cm)	182.1 ± 7.8	182.4 ± 6.6	181.3 ± 6.6	190.0 ± 9.9	.068	0.94
Forearm circumference (cm)	30.5 ± 3.6	29.1 ± 2.7	27.5 ± 1.8	31.0 ± 2.6	.072	0.90
Upper arm circumference (cm)	36.0 ± 5.7	33.3 ± 5.2	31.7 ± 2.6	35.2 ± 3.2	.220	0.70
Skinfolds						
Forearm (mm)	8.2 ± 3.8	6.0 ±2.2	6.8 ± 3.2	6.1 ± 1.9	.272	0.67
Biceps (mm)	9.6 ± 6.2	6.2 ± 2.6	5.5 ± 2.5	6.0 ± 1.8	.080	0.90
Triceps (mm)	12.2± 3.6	10.0 ± 5.3	7.2 ± 3.9	9.7 ± 3.4	.138	0.81
Suprailiac (mm)	20.4 ± 6.3	15.4 ± 7.1	13.2 ± 8.5	16.2 ± 3.8	.149	0.81
Subscapular (mm)	16.8± 6.4	16.3 ± 8.0	13.1 ± 7.9	17.5 ± 4.1	.606	0.46
Agility						
T-test (sec)	17.7 ± 2.0	15.7 ± 1.1	17.1 ± 1.8	17.1 ± 1.8	**.046***	1.03
Figure-of-Eight test (no. of laps)	7.7 ± 1.2	9.0 ± 0.8	8.7 ± 0.5	8.7 ± 1.1	**.026***	0.90

Legend: Data are presented as mean ± standard deviation (Mean ± SD); p - statistical significance of one-way analysis of variance (ANOVA) or Kruskal-Wallis (Figure-of-Eight test); * - $p < 0.05$; ES – effect size (Cohen's d).

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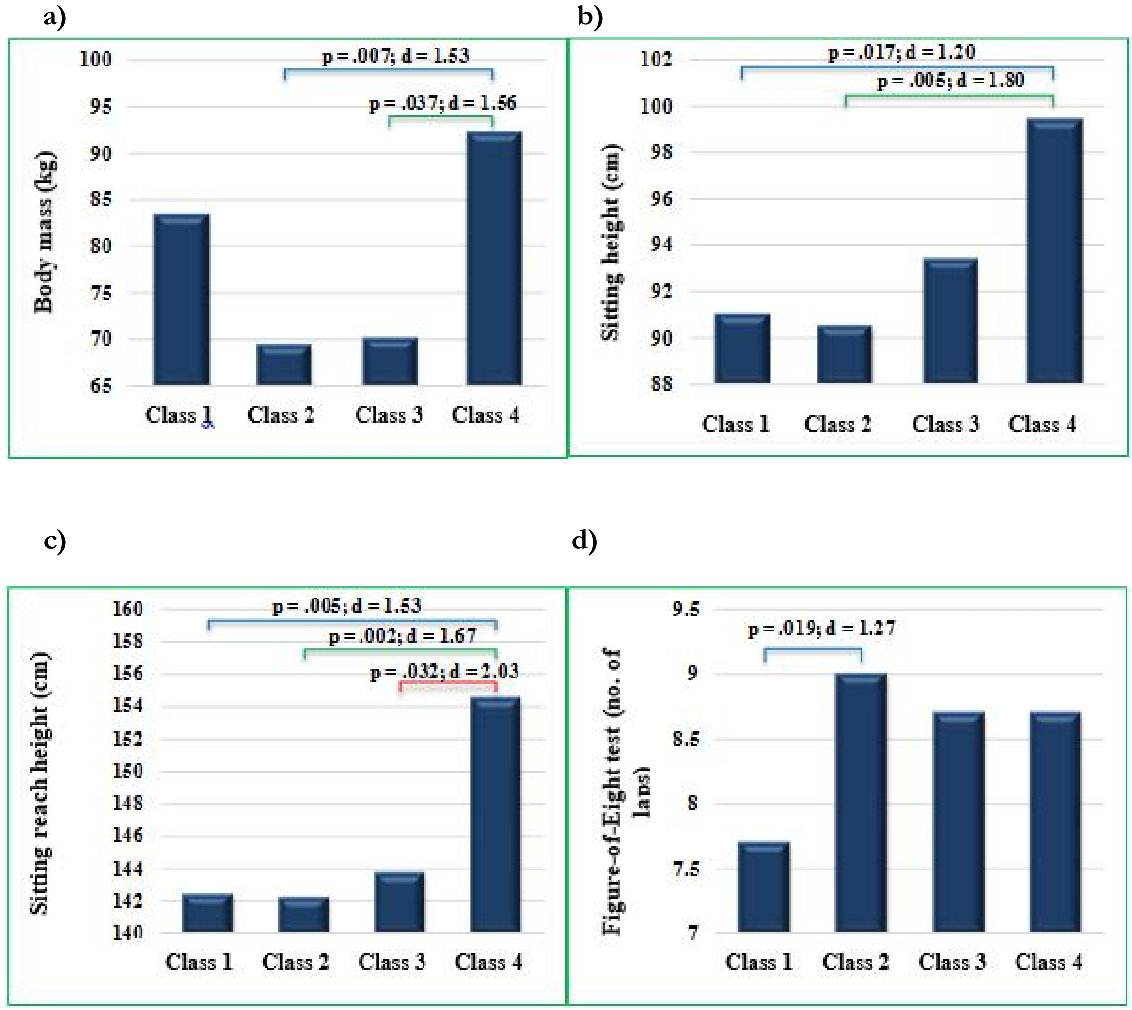

Chart 1. *Results of Bonferroni post-hoc analysis. (a) body mass; (b) sitting height; (c) sitting reach height and (d) figure-of-eight test.*

Further analysis of the post-hoc test determined between which functional classes there was a significant difference in the mentioned variables (Chart 1). More precisely, body mass (Class 2 vs. Class 4, d = 1.53; Class 3 vs. Class 4, d = 1.56), sitting height (Class 1 vs. Class 4, d = 1.20; Class 2 vs. Class 4, d = 1.80), sitting reach height (Class 1 vs. Class 4, d = 1.53; Class 2 vs. Class 4, d = 1.67; Class 3 vs. Class 4, d = 2.03) and figure-of-eight test (Class 1 vs. Class 2, d = 1.27).

The analysis of variance revealed significant differences between the classes in the T-test, however, the post-hoc analysis found that the differences observed between Class 1 and Class 2 were still above the significance threshold (p = 0.054), and for that reason they were not shown graphically.

The results of the correlation analysis are shown in Table 3. Significant moderate positive correlations were found between sitting height and functional classification, as well as between sitting reaching height and functional classification.

Other correlation coefficients show that there is no significant relationship between anthropometric characteristics and agility, agility and functional classification, or other anthropometric characteristics and player functional classification.

Table 3. *Correlation between anthropometric characteristics, agility and functional classification of wheelchair basketball players*

Spearman's (*r*)	**T-test**	**Figure-of-Eight test**	**Class**
Sitting height	.159	-.019	**.456****
Sitting reach height	.089	-.020	**.393***
Arm span	-.199	.125	.214
Forearm circumference	.101	-.110	-.046
Upper arm circumference	.044	-.113	-.126
Forearm skinfold	-.033	.184	-.116
Bicep skinfold	.044	-.157	-.274
Triceps skinfold	-.039	-.170	-.288
Suprailiac skinfold	.179	-.222	-.273
Subscapular skinfold	.092	-.006	-.020
Class	.019	.252	/

** - correlation is significant at the $p < 0.01$ level; * - correlation is significant at the $p < 0.05$ level.

DISSCUSION

This study was conducted with the aim of determining: (1) differences in anthropometric characteristics and agility between different functional classes of wheelchair basketball players and (2) the association between anthropometric characteristics and agility with the functional classification of wheelchair basketball players. The results showed that there were significant differences with very large effects between classes in body mass, sitting height, and sitting reach height (d = 1.31; 1.31; 1.46, respectively), as well as large effects in the tests for the assessment of the Figure-of-Eight and the T-test (d = 0.90; 1.03, respectively). Furthermore, the correlation analysis revealed a moderate but significant relationship between sitting height and sitting reach height and functional classes of players. Finally, no significant association was recorded between anthropometric characteristics and agility, nor between agility and functional classification.

Significant differences in body mass with very large effects occurred between Class 4 players who had a significantly higher body mass compared to players belonging to Classes 2 and 3, but not significantly higher compared to players with the lowest functional capacity (Class 1). The results are in agreement with previous research, where it was also confirmed that players of higher classes are heavier compared to their teammates of lower classes (Gil et al., 2015; Yanci et al., 2015; Zacharakis et al., 2020). Such results are expected. However, it is interesting that Class 1 players have a higher body mass than Class 2 and 3 players, but not significantly. A possible explanation for this trend is that Class 4 players have the highest body mass because they have full functional capacity. Body weight declines in lower grade players due to the nature of injuries or illnesses that lead to atrophy in the lower body or amputation of one or both lower limbs. However, as a consequence of the excessive reduction of muscle mass, due to atrophy of the muscles of the lower extremities and reduced trunk control, there is an increase in the fat component (Laughton et al., 2009) and a different distribution of adipose tissue and thus excessive accumulation in the abdominal region (Buchholz & Bugaresti, 2005; Cavedon et al., 2018). In present study, no significant correlation was recorded between body mass and functional classification, while Gil et al. (2015) reported a significant positive correlation (r = .68). This result should be viewed with caution considering that the research included a small number of respondents (N = 13). Sitting height and sitting reach height differed significantly between classes. It is evident that players of Class 4 have a significantly higher sitting and reaching height compared to players of lower classes (except for sitting height between Classes 4 and 3). Such differences between players of higher and lower classes have been confirmed in previous research (Cavedon et al., 2015; Gil et al., 2015; Yanci et al., 2015). However, in Greek wheelchair basketball players the differences were not significant (Zacharakis et al., 2020). Also, our results showed that sitting and sitting reach height significantly positively correlate with the functional classification of players. Similar results were reported by Cavedon et al. (2015) in 52 young wheelchair basketball players, also classified into four groups. Cavedon et al. (2015) further explain that the sitting reach height is achieved when the body is extended so that the angles of the shoulder and elbow joints approximately reach an angle of 180° and such a position depends on the amplitude of movement of the upper body parts. Furthermore, some spastic disorders are often associated with reduced range of motion in one or more joints, thereby reducing the player's ability to lift the upper limbs. In summary, the degree of impairment of a player determines the seated reach height, which is considered to be significantly related to performance in field tests to assess speed, agility and situational motor skills of wheelchair basketball players (Cavedon et al., 2015; Cavedon et al., 2018), which was not confirmed in our study. Accordingly, further research is needed in order to obtain additional information about the relation of sitting reach height with various kinetic and kinematic parameters that are part of wheelchair management, but also the success in performing certain elements of the game itself. The results of tests for the assessment of agility showed that there are significant differences in relation to the functional classification. It is interesting that in agility tests the best results were achieved by players of Class 2, and the weakest by players of Class 1. However, a significant difference between these classes was confirmed only in the Figure-of-Eight test. The T-test revealed significant differences between all classes, but not individually between classes, which is in agreement with the findings of several studies (Yanci et al., 2015; Molik et al., 2010; Tachibana et al., 2019). Previous research also reported that lower class players achieved better results in other tests of agility (figure-of-eight, slalom, etc.) and acceleration (5 m, 20 m) compared to higher class players (Gil et al., 2015; Tachibana et al. al., 2019; Ceruso et al., 2022).

A possible explanation is that players of lower classes (functional abilities) are more dependent on wheelchairs during daily activities. As a result, they have different propelling biomechanics and energy efficiency compared to higher class players and even fully functional players (Croft et al., 2013). Also, Gil et al. (2015) reported that there was a significant association between years of wheelchair use and the ability to perform 5 and 20 m acceleration and agility tests. Therefore, it is not surprising that in our study, Class 2 players, who use their wheelchairs for daily activities, while having better trunk stability than class 1 players, performed better in agility tests compared to higher class players who use wheelchairs for training and competition only. In present study, no association of agility tests with functional classification were recorded, which is in agreement with the research of Ceruso et al. (2022) where also no correlation was noted between the official IWBF classification and field tests for speed, and agility.

It should be noted that this study has certain limitations. The first and main limitation is the small sample of participants, which to some extent reflected on the results in terms of concealing potential differences between functional classes, especially for some variables where there was a large effect of differences. A small sample of participants is a frequent problem in research with such a specific sample and brings with it certain difficulties in drawing conclusions and comparing results. Second, in this study the testing was conducted during the tournament, as this was the only way to collect a sample with similar characteristics (elite wheelchair basketball players from the region). Given the time constraints during testing, the choice of motor skills and ability tests was limited.

CONCLUSION

Based on the analyzed results, we came to the conclusion that body mass, sitting height and sitting reach height are anthropometric characteristics that differ significantly in relation to the functional classification of players. The difference between players of higher classes compared to players of lower functional classes is especially noticeable. Also, agility as a very important ability to maneuver the wheelchair differs in relation to the functional classification, but more in favor of players of lower classes. Future research should repeat this similar study, but on a larger sample in order to obtain more precise information about the sensitivity of the functional classification, which some authors consider to be subject to revision. Also, the database of motor tests adapted and validated for wheelchair basketball players should be expanded. Future research should also examine to a greater extent the biomechanical parameters of wheelchair basketball players and their potential impact on classification, motor skills, and performance indicators in the game.

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SAŽETAK

Ciljevi ovog istraživanja su bili da se utvrde: (1) razlike u antropometrijskim karakteristikama i agilnosti između različitih funkcionalnih klasa košarkaša u kolicima i (2) povezanost između antropometrijskih karakteristika i agilnosti sa funkcionalnom klasifikacijom košarkaša u kolicima. Uzorak ispitanika činilo je 40 košarkaša u kolicima, uzrasta 33.9 ± 11.2 godina. Procenjivane su antropometrijske karakteristike (longitudionalne i cirkularne dimenzije, kožni nabori), a za procenu agilnosti korišćeni su modifikovani T-test i osmica test. Rezultati jednosmerne analize varijanse ukazuju na postojanje značajnih razlika sa veoma velikim efektima između igrača različitih funkcionalnih klasa kod telesne mase, sedeće visine i sedeće dohvatne visine, dok su značajne razlike sa velikim efektima zabeležene kod testova za procenu agilnosti: T-testa i osmice testa. Takođe, rezultati korelacione analize ukazuju na to da postoje značajne umerene pozitivne korelacije sedeće visine i dohvatne visine sa funkcionalnom klasifikacijom.

Ključne reči: *invaliditet, t-test, sport, motoričke sposobnosti, sportisti*

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