Toskić, L., Marković, M. (2024) Usability of isotonic dynamometry testing in children and youth In: Dašić, D. (ed) Sporticopedia SMB2024, Vol 2, No 1, 55-66

Original scientific paper
Received: 7.11.2024
Accepted: 5.12.2024

DOI: https://doi.org/10.58984/smbic240201055t

Coresponding author: lazar.toskic@pr.ac.rs

USABILITY OF ISOTONIC DYNAMOMETRY TESTING IN CHILDREN AND YOUTH

Lazar Toskić[1], Milan Marković[2]

Abstract: This study aims to investigate the usability of isotonic dynamometry in children and youth by determining the correlation between isometric dynamometry, which is considered the most valid direct-laboratory method for the assessment of muscle contractile properties in children, and isotonic dynamometry. The sample of the participants was composed of children and youth aged 7 to 19 years divided into 3 groups: younger school age (7-10 y), middle school age (11-14 y) and high school age (15-19 y). Implemented tests were the hand grip strength test (isometric dynamometry) and countermovement jump on the force plates (isotonic dynamometry). The results of Pearson's correlation coefficient revealed that there is no significant correlation between Fmax, RFD and jump height in younger ($r = 0.176$, $p = 0.291$; $r = 0.152$, $p = 0.363$, respectively) and middle school-age children ($r = 0.059$, $p = 0.733$; $r = 0.201$, $p = 0.241$, respectively) while there is a high correlation in the group of high school participants ($r = 0.531$, $p = 0.001$; $r = 0.544$, $p = 0.001$, respectively). This study's results indicate that the isotonic dynamometry method is not valid for implementation in the group of children under the age of 15.

Keywords: : isotonic dynamometry, isometric dynamometry, countermovement jump, hand grip strength test, children and youth

[1] Associate professor, Faculty of Sport and Physical Education, University of Pirština-Kosovska Mitrovica, Dositeja Obradovića bb., Leposavić, Serbia, Faculty of Sport, University ''Union – Nikola Tesla'', phone number: +38162658056, https://orcid.org/0000-0003-3538-3024; E-mail: lazar.toskic@pr.ac.rs

[2] Teaching assistant, Faculty of Sport and Physical Education, University of Pirština-Kosovska Mitrovica, Dositeja Obradovića bb., Leposavić, Serbia, phone number: +381655306919, https://orcid.org/0000-0002-9544-3773; E-mail: milan.markovic@pr.ac.rs

Introduction

Sports diagnostics is an important part of the training process, injury prevention and rehabilitation, selection process etc. in athletes (Abernethy, Wilson, Logan, 1995). Sports diagnostics is also useful in implementation on other subjects, such as children. The proper application of sports diagnostics methods in children and youth can lead to important information about their growth and development and overall health status (Armstrong, Van Mechelen, 2017). The assessment of muscle strength and power is especially important in children in youth (Jones, Stratton, 2000). However, it is necessary to know which kinds of methods and tests are valid to use on this sensitive type of subject.

The direct-laboratory methods, such as dynamometry, are the most valid methods for the assessment of muscle contractile properties, that is, muscle strength and power, and isometric and isotonic dynamometry are considered a ''gold standard'' (Abernethy, Wilson, Logan, 1995). While isometric dynamometry measures the muscle strength manifested in isometric conditions (muscle force, isometric strength), isotonic dynamometry mainly refers to muscle power (Abernethy, Wilson, Logan, 1995; Claudino et al., 2017; Juneja, Verma, Khanna, 2012). One of the most valid, reliable and useful tests of isometric dynamometry is the ''hand grip strength test'' which showed a high correlation with performance and general health, while the most implemented test of isotonic dynamometry is a vertical jump on the force plates (Claudino et al., 2017; Juneja, Verma, Khanna, 2012). Also, hand grip strength test is appropriate for implementation in children and youth (and other subject categories besides athletes), for the reason of task complicity and safety (De Smet, Vercammen, 2001; Häger-Ross, Rösblad, 2002). On the other hand, vertical jumps on the force plates require knowing complex movement and it is mainly reserved for athletes - subjects with training history (Fernandez-Santos et al., 2015; Petrigna et al., 2019). It is important to emphasize that the hand grip strength test has a high correlation with the results of countermovement jump (CMJ) in adults (Thomas et al., 2015).

Accordingly, this study aims to investigate the usability of isotonic dynamometry in children and youth by determining the correlation between isometric dynamometry, which is considered the most valid direct-laboratory method for muscle contractile properties assessment, and isotonic dynamometry. It is hypothesised that there will be a significant correlation between methods.

Methods

Subjects

The sample of the participants was composed of children and youth aged 7 to 19 years divided into 3 groups:

- younger school age YS (7-10 y, N = 38),
- middle school age MS (11-14 y, N = 36),
- high school age HS (15-19 y, N = 33).

All participants were healthy (no injuries or illness), rested and voluntarily participated in the study. The study was conducted in accordance with the ethical standards of the Declaration of Helsinki and the rules of the Ethics Committee of the Faculty of Sport and Physical Education and Sport.

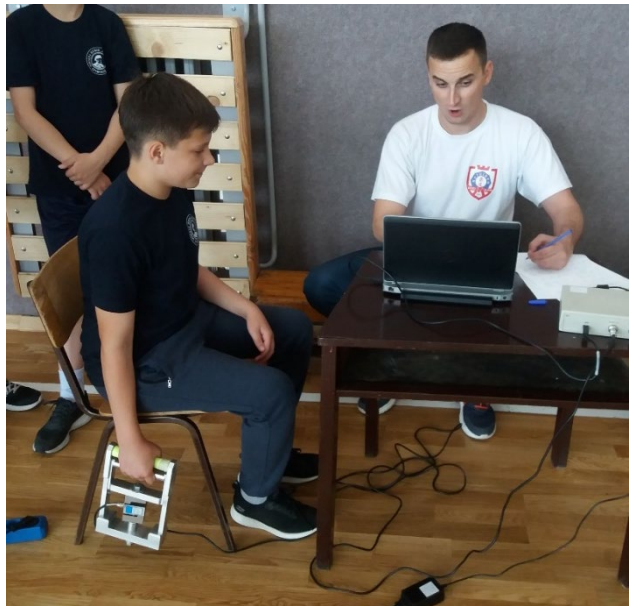
Procedures

Muscle isometric strength was measured using the isometric dynamometry method, using a hand-held dynamometer and a handgrip strength test, where maximal force (Fmax) and rate of force development were measured (RFD) (Figure 1). The measurement procedure is as follows (Toskić et al., 2019):

- the subject sits on a chair, with the back straight and not leaning;
- the subject takes the hand-held dynamometer with a full grip in the hand that is in the elbow position in maximum extension next to the body;
- at the signal of the measurer, the subject contracts the flexor muscles of the hand, i.e. squeezes the dynamometer as hard and as fast as possible.

Before the measurement, the subjects were familiarized with the measurement procedure and had several trial attempts. Also, data was taken from the subject from the dominant side of the body (hand). Measurements were performed twice with the right and left hand, i.e. the dominant and non-dominant, with breaks between measurements. As a final result, the highest values from the two attempts of the dominant hand were taken.

Figure 1. *Hand grip strength test*



Muscle power was measured by isotonic dynamometry using force platforms (K-Deltas, Kinvent, Montpellier, France, Figure 2) and the Countermovement Jump test (CMJ). The measurement procedure is as follows (Marković et al., 2004):

- the subject stands on the platform at a marked location, with feet parallel and hip-width apart;
- hands are on the hips;
- from this position, the subject lowers and quickly rises, i.e. extends all joints of the lower extremities and jumps vertically upwards, keeping the hands on the sides at all times;
- three jumps are performed;
- the subject is asked to jump as high as possible, not to bend the knees during the jump, and to land at the same location from which they jumped.

Before measuring muscle strength, the subjects were introduced to the test, had practice attempts, and had to warm up before the measurement (5-10 min., jumping, squatting, running, stretching) (Toskić et al., 2019; 2020). As the final result, the maximum values of power and jump height from three attempts were taken.

Measurements were conducted in the morning, where body mass and height were first measured. After the warm-up protocol, the measurements of the hand grip strength and CMJ on the force plates were conducted. All measurements were conducted by the same experienced staff.

Figure 2. *Force plates*

Statistical analysis

The statistical procedures used in the study included descriptive statistics (Mean, SD), and Person correlation analysis. The statistical significance level was 95% with $p < 0.05$. All the statistical procedures were performed in the SPSS19 (IBM) program, IBM Armonk, New York, NY, USA.

Results

Table 1 presents descriptive statistics of measured parameters of isometric strength of hand flexor muscles (Fmax and RFD) and muscle power of knee joint extensor muscles (CMJ). It can be noticed that all values rise with the age of the participants, having the lowest values in YS and the highest values in the HS group.

Table 1. *Descriptive statistics of measured parameters*

		Mean	Std. Deviation	Minimum	Maximum	Skewness	Kurtosis
YS	**CMJ (cm)**	15.7895	3.84256	8	23	.028	-.883
	Fmax (N)	129.4737	30.25454	79	203	.541	.055
	RFD (N/s)	698.6053	237.11242	289	1214	.339	-.628
MS	**CMJ (cm)**	19.4444	4.61949	11	30	.278	-.289
	Fmax (N)	192.9167	52.40631	99	315	.379	-.417
	RFD (N/s)	1263.4167	413.38694	417	2102	.096	-.217
HS	**CMJ (cm)**	28.3636	6.48468	18	43	.430	-.432
	Fmax (N)	339.9697	72.03232	227	508	.498	-.156
	RFD (N/s)	2294.1515	571.25706	1504	3624	.943	-.055

Figures 3 to 8 present the results of a correlation analysis between parameters of isometric (Fmax and RFD) and isotonic dynamometry. It can be concluded that there is no significant correlation between parameters CMJ, Fmax and RFD in YS (r = 0.176, p = 0.291; r = 0.152, p = 0.363, respectively) and MS (r = 0.059, p = 0.733; r = 0.201, p = 0.241, respectively) groups, while these correlations are high in the HS group (r = 0.531, p = 0.001; r = 0.544, p = 0.001, respectively).

Figure 3. *Correlation between CMJ and Fmax in younger school age group*

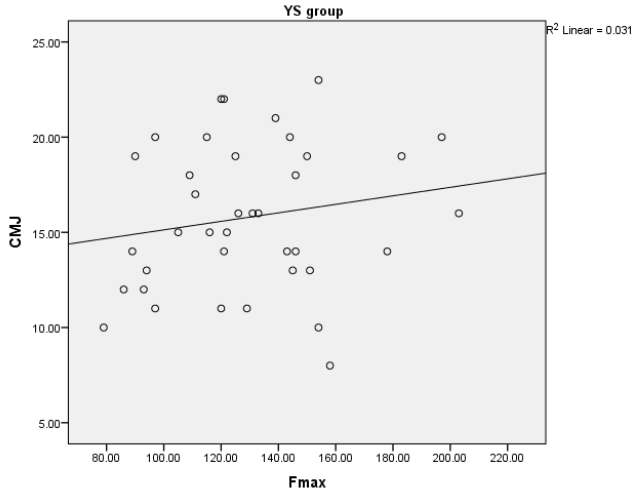


Figure 4. *Correlation between CMJ and RFD in younger school age group*

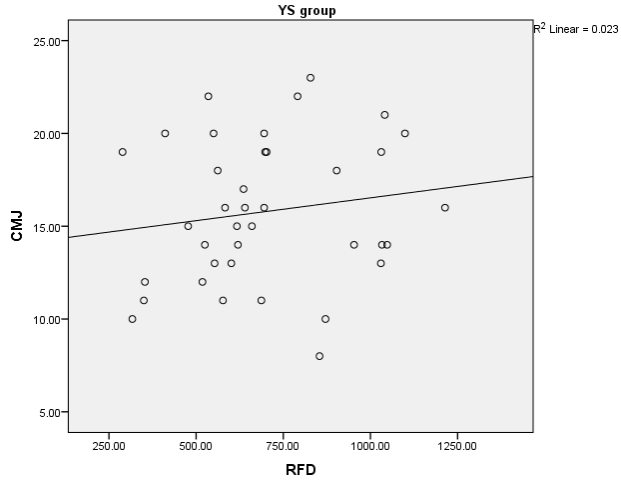


Figure 5. *Correlation between CMJ and Fmax in middle school age group*

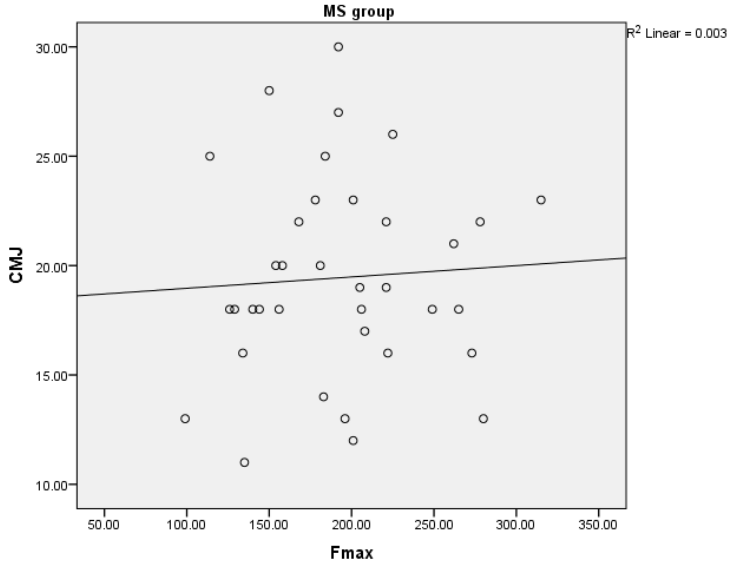


Figure 6. *Correlation between CMJ and RFD in middle school age group*

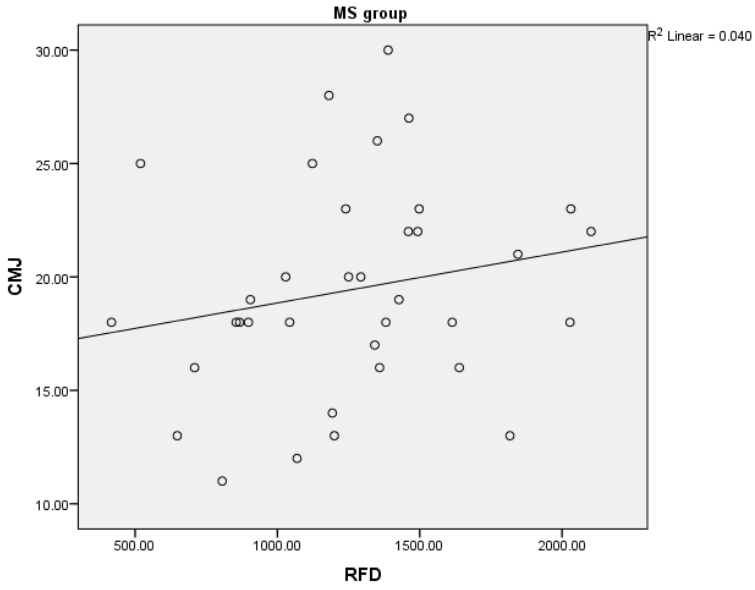


Figure 7. *Correlation between CMJ and Fmax in higher school age group*

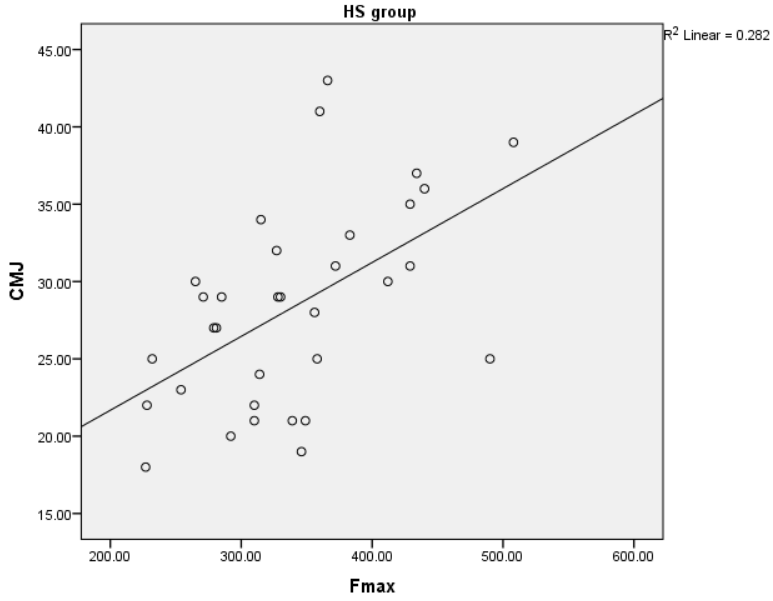
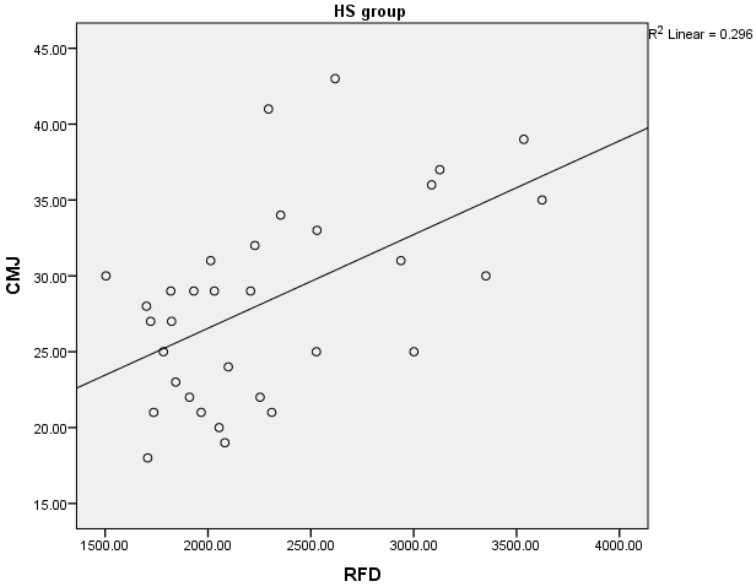


Figure 8. *Correlation between CMJ and RFD in higher school age group*



Discusion

This study aims to investigate the usability of isotonic dynamometry in children and youth. The main problem of isotonic dynamometry implementation in children and youth is validity, since it involves complex movements (Fernandez-Santos et al., 2015; Petrigna et al., 2019). On the other side, isometric dynamometry has been shown as a method valid for use in these age groups (De Smet, Vercammen, 2001; Häger-Ross, Rösblad, 2002). Accordingly, the usability of isotonic dynamometry was investigated by determining the correlation between isometric dynamometry and isotonic dynamometry. It is assumed that a high correlation between the results of isotonic and isometric dynamometry in children and youth will indicate the validity and usability of isotonic dynamometry in children and youth since it has shown that the hand grip strength test has a high correlation with the results of countermovement jump (CMJ) in adults (Thomas et al., 2015).

The main result of this study is that there are no significant correlation between parameters of isotonic dynamometry CMJ, and isometric dynamometry parameters Fmax and RFD in YS ($r = 0.176$, $p = 0.291$; $r = 0.152$, $p = 0.363$, respectively, Figure 3 and 4) and MS ($r = 0.059$, $p = 0.733$; $r = 0.201$, $p = 0.241$, respectively, Figure 5 and 6) groups, while these correlations are high in the HS group ($r = 0.531$, $p = 0.001$; $r = 0.544$, $p = 0.$, respectively, Figure 7 and 8). These results indicate that isotonic dynamometry, namely the CMJ test on force plates, is not appropriate for application in children and youth under the age of 15.

These results are to some extent expected. Both isotonic and isometric dynamometry are highly usable and valid for implementation in adults, especially in athletes or physically active participants (Abernethy, Wilson, Logan, 1995; Claudino et al., 2017; Juneja, Verma, Khanna, 2012). These methods are widely used in testing muscle isometric strength and muscle power, since it has shown that the results of these tests are highly correlated with sports performance and general health (Cronin et al., 2017; Juneja, Verma, Khanna, 2012). However, isometric dynamometry has shown greater validity and usability, especially in untrained subjects (Abernethy, Wilson, Logan, 1995). Additionally, the hand grip strength test is one of the tests that is widely used in all subject categories (young, adult, healthy, non-healthy etc.) (Bobos et al., 2020). The reason for this phenomenon is the simplicity of the motoric task during measurements and safety. Namely, most isometric dynamometry tests, especially hand grip strength test, are easy to perform with no previous knowledge of the movement. Additionally, the possibility of injury in this test is minimal. On the other hand, isotonic dynamometry, namely CMJ jump on the force plates as one of the most popular and used, could be hard to implement in children due complex motoric task, especially in untrained subjects. Also, since dynamic muscle contraction is present, the injury risk is present. Accordingly, a low correlation between results of isotonic dynamometry

(CMJ) and isometric dynamometry (hand grip strength test) in children and youth under the age of 15 is expected since most of the children is not familiar with the motoric task in CMJ, and thus manifested inconsistent values, unlike the hand grip strength test. Subjects above 15 years are mature from the aspect of movement, and some of them have training experience, thus they have consisted results in the CMJ test, similar to the hand grip strength test.

Conclusion

The results of this study showed no significant correlation between parameters of isotonic dynamometry CMJ, and isometric dynamometry parameters Fmax and RFD in YS and MS groups, while these correlations are high in the HS group. These results indicate that isotonic dynamometry, namely the CMJ test on force plates, is not appropriate for application in children and youth under the age of 15.

Author Contributions

Conceptualization, L.T..; **Resources**, M.M. **Methodology**, L.T and M.M.; **Investigation**, L.T; **Data curation**, M.M; **Formal Analysis**, L.T.; **Writing – original draft**, L.T.; **Writing – review & editing**, L.T.

All authors have read and agreed to the published version of the manuscript.

Reference

1. Abernethy, P., Wilson, G., & Logan, P. (1995). Strength and power assessment. Sports Medicine, 19(6), 401-417.
2. Armstrong, N., & Van Mechelen, W. (Eds.). (2017). Oxford textbook of children's sport and exercise medicine. UK: Oxford University Press.
3. Bobos, P., Nazari, G., Lu, Z., & MacDermid, J. C. (2020). Measurement properties of the hand grip strength assessment: a systematic review with meta-analysis. Archives of physical medicine and rehabilitation, 101(3), 553-565.
4. Claudino, J. G., Cronin, J., Mezêncio, B., McMaster, D. T., McGuigan, M., Tricoli, V., ... & Serrão, J. C. (2017). The countermovement jump to monitor neuromuscular status: A meta-analysis. Journal of science and medicine in sport, 20(4), 397-402.
5. Cronin, J., Lawton, T., Harris, N., Kilding, A., & McMaster, D. T. (2017). A brief review of handgrip strength and sport performance. The Journal of Strength & Conditioning Research, 31(11), 3187-3217.

6. De Smet, L., & Vercammen, A. (2001). Grip strength in children. Journal of Pediatric Orthopaedics B, 10(4), 352-354.
7. Fernandez-Santos, J. R., Ruiz, J. R., Cohen, D. D., Gonzalez-Montesinos, J. L., & Castro-Piñero, J. (2015). Reliability and validity of tests to assess lower-body muscular power in children. The Journal of Strength & Conditioning Research, 29(8), 2277-2285.
8. Häger-Ross, C., & Rösblad, B. (2002). Norms for grip strength in children aged 4–16 years. Acta Paediatrica, 91(6), 617-625.
9. Jones, M. A., & Stratton, G. (2000). Muscle function assessment in children. Acta Paediatrica, 89(7), 753-761.
10. Juneja, H., Verma, S. K., & Khanna, G. L. (2012). Isometric strength and its relationship to dynamic performance: a systematic review. Journal of exercise science and physiotherapy, 6(2), 60-69.
11. Markovic, G., Dizdar, D., Jukic, I., & Cardinale, M. (2004). Reliability and factorial validity of squat and countermovement jump tests. The Journal of Strength & Conditioning Research, 18(3), 551-555.
12. Petrigna, L., Karsten, B., Marcolin, G., Paoli, A., D'Antona, G., Palma, A., & Bianco, A. (2019). A review of countermovement and squat jump testing methods in the context of public health examination in adolescence: reliability and feasibility of current testing procedures. Frontiers in physiology, 10, 1384.
13. Thomas, C., Jones, P. A., Rothwell, J., Chiang, C. Y., & Comfort, P. (2015). An investigation into the relationship between maximum isometric strength and vertical jump performance. The Journal of Strength & Conditioning Research, 29(8), 2176-2185.
14. Toskić, L., Dopsaj, M., Stanković, V., & Marković, M. (2019). Concurrent and predictive validity of isokinetic dynamometry and tensiomyography in differently trained women and men. Isokinetics and Exercise Science, 27(1), 31-39.
15. Toskić, L., Dopsaj, M., Toskić, D., & Marković, M. (2020). Isokinetic muscle power of the knee extensor and flexor muscles among differently trained people in relation to gender. Human Movement, 21(3), 81-89.
16. Toskić, L., Stijepović, V., Pantić, D., Dopsaj, M., Marković, S., Lilić, Lj., Toskić, D., & Žugić, Z. (2019). Analysis of the ski instructor physical condition from the aspect of muscle force manifestation: pilot study. In V. Stanković, & T. Stojanović (Eds.) Book of the proceedings the sixth international scientific conference – Anthropological and teo-anthropological views on physical activity from the time of Constantine the Great to modern times (pp. 89-96). Kopaonik, Serbia: Faculty of sport and physical education, University of Priština - Kosovska Mitrovica.

Toskić, L., Marković, M. (2024) Usability of isotonic dynamometry testing in children and youth In: Dašić, D. (ed) Sporticopedia SMB2024, Vol 2, No 1, 53-64