DE GRUYTER OPEN

Acta Facultatis Educationis Physicae Universitatis Comenianae
Vol. 57 No 1 2017

IMPORTANCE OF PERFORMING EXPERIENCE IN STRENGTH TRAINING PERIODIZATION

Adrián Novosád[*1], Gabriel Buzgó[*2,3], Peter Keszegh[*2], Jakub Chudý [*2], Matej Halaj[*1], Tomáš Kolonyi[*4]

[*1] Department of Track and Field, Faculty of Physical Education and Sports, Comenius University in Bratislava,
[*2] Department of Sports Kinanthropology, Faculty of Physical Education and Sports, Comenius University in Bratislava,
[*3] Education Committee, Slovak Weightlifting Federation
[*4] Institute of Anatomy, Faculty of Medicine, Comenius University in Bratislava

Summary: Proper mastering of a training means seems to be an important determinant of the quality of strength training. Aim of the paper is to examine the differences in strength in relation to squat-performing experience and to offer a way of improving performance by means of increasing the quality of squat technique. **Methods 1.** Subjects were divided into two groups according to their previous experience with performing squat: a group of inexperienced (n = 9; age: 21.1 years ± 2.37; height: 179.2 cm ± 8.18; weight: 70.0 kg ± 7.38) and experienced (n = 9; age: 24.0 years ± 1.07; height: 182.1 cm ± 4.14; weight: 81.2 kg ± 4.29). We carried out a test of maximal isometric strength in deep squat ($ISOmax_{50^\circ}$) and a modified diagnostic set (Fitro Force Plate) which consisted of repetitions of heel raised deep squats with a gradually increasing external loading ($Fmax_{BW+(0\text{-}100\%)}$). Posture and the body segments of the participants were not corrected during these tests. Mann-Whitney U test (α=0.05) was used to evaluate the data obtained. **Results 1.** After comparing the differences in the maximal value of force curve in dynamic muscular mode ($Fmax_{BW+(0\text{-}100\%)}$) and the maximal isometric force in deep squat ($ISOmax_{50^\circ}$) between the groups we found significantly bigger differences in the group of experienced when the resistance represented +75 % (Δ 279.0 N) and +100 % of body weight (Δ 332.2 N). **Methods 2.** Eleven inexperienced subjects (age: 22.1 years ± 1.52; weight: 78.2 kg ± 2.84) completed a short term experiment (with 4 training sessions in weeklong microcycle). The purpose was to practise deep squat without any content of targeted strength development.

DOI 10.1515/afepuc-2017-0001

No control group was included. Initial and final measurements included the rate of force development test ($RFD_{50°,90°,140°}$, 0-200 ms), the maximal isometric strength test ($ISOmax_{50°,90°,140°}$) and the diagnostic set for deep squat (Fitro Dyne Premium). Wilcoxon T-test was used for further analyses ($\alpha = 0.01$; $\alpha = 0.05$). **Results 2.** We found statistically significant increments of $ISOmax_{50°}$ (Δ 89.45 N, $p < 0.01$), $ISOmax_{90°}$ (Δ 45.63 N, $p < 0.05$), $RFD_{50°(0\text{-}200ms)}$ (Δ 0.42 $N.ms^{-1}$, $p < 0.05$), $RFD_{90°(0\text{-}200ms)}$ (Δ 0.47 $N.ms^{-1}$, $p < 0.05$) and mean power output (Pmean) of entire diagnostic set (Δ 38.8 W, $p < 0.01$). **Conclusions.** Increases in the difference in variations between the groups starting from the resistance of 50 % of body weight confirms the recommendations of using lower weights for beginners for the purpose of strength development. Based on the results we conclude that a short-term training programme of deep squat practise (without any intention of improving strength performance) has positive effect on selected strength parameters.

Key words: Deep squat, motion-performing experience, rate of force development, maximal isometric force, maximal value of force curve, power, range of motion

Introduction

Correct organisation of a training unit ensures positive and efficient interaction of training variables. Monitoring the acute effects of training session and innovating its content with respect to the abilities of individual athletes improves the optimization of training intervention. Choosing appropriate training means is another important issue as it influences the parameters of other training variables and eventually affects the quality of strength training. This topic is studied in papers by Laczo et al. 2012 (comparison of special technical and special strength training means) and Buzgó et al. 2014 (comparison of strength parameters in various training means using squat exercise). Importance needs to be devoted to the sphere of mastering the performance of training means. Aim of the paper is to point out the relation between different level of strength performance and squat-performing experience. It also offers options of increasing the strength by means of improving the quality of movement technique. Providing the results of our research, we want to contribute to the strategies of modelling of strength training programs and to point out the importance of technical preparation for the development of performance capacity.

The ability to produce power in relation to movement-performing experience

A change in motor program represents an adaptation of organ and functional systems in the body (Neumann et al. 2007). Improved neuro-muscular activation and coordination of muscle groups can have a significant impact on strength development (Zatsiorsky & Kraemer 2006). Different levels of the ability to produce power depending of squat-performing experience proves the importance of technical preparation.

Change in strength parameters by means of a short-term training

It is evident that different squat-performing experience is connected with different level of strength performance. Different quality of performing a training means seems to be one of many reasons. Mastering the performance of training means is according to Lehnert & Novosad (2010) one of the factors influencing muscular strength. They define functional strength training as a training for optimization of muscular functions – movement training, not muscle training. The improvement of neuromuscular system activity is one of the changes which occur during adaptation process, as mentioned by Neumann et al. (2007). Unnecessary and redundant movements are eliminated in the first stage of this process which leads to the optimization of movement. The authors mention that the adjustment of motor abilities lasts about 10 days. It creates an assumption of better control over the exercise and the utilization of neuroregulatory adaptation processes, thus ensuring the progress of selected motor ability.

Methods 1

Eighteen participants completed the study. Based on their previous experience with performing deep squat they were divided into a group of inexperienced (n = 9; age: 21.1 years ± 2.37; height: 179.2 cm ± 8.18; weight: 70.0 kg ±7.38) and experienced (n = 9; age: 24.0 years ± 1.07; height: 182.1 cm ± 4.14; weight: 81.2 kg ± 4.29). Both groups carried out a test of maximal isometric force in deep squat ($ISOmax_{50^\circ}$) and a diagnostic set modified for heel raised deep squat with various additional resistance (+0 %, +25 %, +50 %, +75 % and +100 % of body weight).

Maximal isometric strength test was carried out to find out the ability to produce power in deep squat. The angle in knee joint (50˚) during this test was chosen according to the previous studies of Fehér (2006), Tihanyi (1998) and Vanderka et al. (2012). Fitro Force Plate, a dynamometric diagnostic device, was used to monitor the force curve. Posture of the participants was not corrected.

A modified diagnostic set (DS) consisted of repetitions of heel raised deep squats with a gradually increasing external loading. Fitro Force Plate, a dynamometric diagnostic device, was used to monitor maximal force and force curve in low position of the exercise. Fitro Dyne Premium, an isoinertial diagnostic device, was used to monitor power, range and velocity of concentric phase of the movement (Schickhofer 2010). External resistance (0 %, 25 %, 50 %, 75 %, and 100 % of body weight) was set in the software together with body weight. Posture and body segments of the participants were not corrected. The eccentric phase of the movement was performed at individual pace while the concentric one was carried out with maximal effort. The purpose of simultaneous isoinertial measurements was to monitor and control the range of motion during squats with external resistances as well as to differentiate the best trial. Nonparametric Mann-Whitney U test was used to compare the differences between the independent groups ($\alpha = 0.05$).

Results 1

Parameters of maximal isometric force in deep squat and maximal value of force curve in dynamic muscular mode were analysed. The range of motion and power exerted during squats with various external resistances provide a more detailed view of differences in strength performance between the groups.

Isometric force in deep squat was greater in the experienced, both including and excluding body weight: Δ 435.6 N (20.86 %) and Δ 325.7 N (25.22 %), respectively. With increasing the resistance, the range of motion decreased by 6.2 cm (Δ 7.6 %) and 2.2 cm (Δ 2.4 %) in inexperienced and experienced, respectively. The decrease was more pronounced during squats with higher resistance. The difference between average power output of inexperienced (1,055.3 W) and experienced (1,451.4 W) group was 396.1 W. This result suggests the difference in power output between the groups. With increasing the resistance, the power output decreased in both groups. However, the decrease occurred sooner in the group of inexperienced. Relative power output [$W.kg^{-1}$] was decreasing in both groups: by 52.1 % and 38.6 % in inexperienced and experienced subjects, respectively.

One of the aims of this paper is to point out the differences in the level of strength performance in relation to squat-performing experience. We evaluated the effect of squat-performing experience on the ability to produce power in dynamic muscular mode by comparing the differences between the maximal value of force curve in dynamic muscular mode ($Fmax_{BW+(0-100\%)}$) and the maximal isometric force in deep squat ($ISOmax_{50^{\circ}}$) in the groups. The differences of variances in these parameters between the groups were evaluated. We hypothesised a more pronounced difference between the maximal value of force curve ($Fmax_{BW+(0-100\%)}$) and the maximal isometric force ($ISOmax_{50^{\circ}}$) in the group of experienced subjects.

Figure 1 shows median and range of differences between absolute values of $Fmax_{BW+(0-100\%)}$ and $ISOmax_{50^{\circ}}$ between the groups. Fmax exceeded ISOmax, starting from the resistance of +25 % of body weight. The graph also shows the tendency of growing differences in these parameters between the groups, starting from the resistance of 50 % of body weight. This tendency is statistically significant ($p < 0.05$) in cases when the resistance represented 75 % and 100 % of body weight. However, substantial variability of data needs to be taken into consideration.

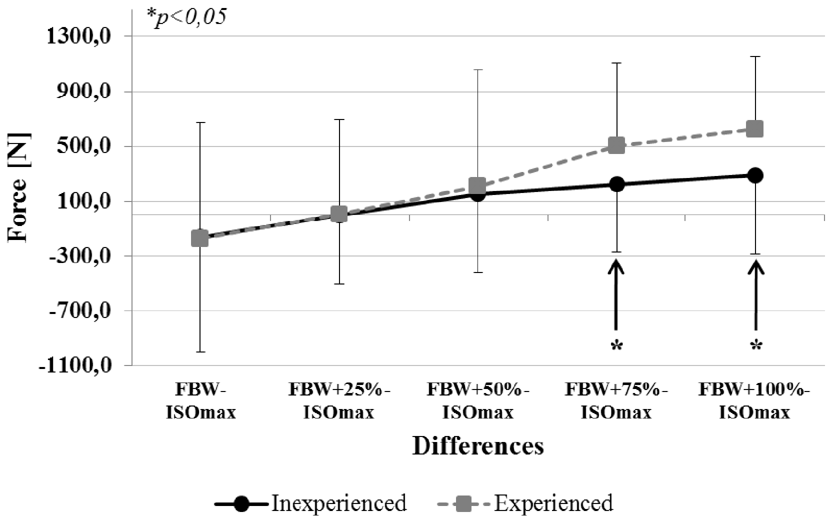

Figure 1

Median and range of differences between absolute values of $Fmax_{BW+(0-100\%)}$ and $ISOmax_{50^\circ}$ between the groups (Inexperienced, Experienced)

Discussion 1

Significance of differences in $ISOmax_{50^\circ}$ and F_{BW} +75 % and +100 % between the groups is confirmed also by the biomechanical measures described in the previous parts of the paper. Zatsiorsky & Kraemer (2014) analysed the mechanical conditions of reaching the maximal force values in isometric and dynamic muscular mode. They explain that specific training can suppress the inverse myotatic reflex, allowing to react to increasing external resistance without a decrease in exerted muscle force. Based on this finding we assume that the differences in force exerted at the resistance of +75 % and +100 % of body weight between the groups could be caused by varying ability to produce power (squat-performing experience), which would be connected with the adaptation process of attenuated protective reflexes and increased excitability threshold. We assume that in the group of inexperienced subjects, the intervention at resistance of +75 % and +100 % of body weight led to inverse myotatic reflex through the activation of Golgi receptors. This was not the case in the group of experienced subjects. Similar explanation of differences of variances in the maximal value of force curve during squat ($Fmax_{BW+(0-100\%)}$) and the maximal isometric force during deep squat ($ISOmax_{50^\circ}$) between the groups is mentioned also by Vanderka (2008, 2013), Vanderka & Kampmiller (2012) and Tihanyi (1999).

Methods 2

Eleven subjects (age: 22.1 years ± 1.52; weight: 78.2 kg ± 2.84) without any previous deep squat-performing experience completed a short term experiment. It was a five-day training programme of practising deep squat lasting 5 (7) days and consisting of 4 training sessions (lasting no more than 60 minutes). The purpose of these sessions was to practise and improve deep squat without any intentions to improve strength. No control group was included.

Initial and final measurements of strength abilities were carried out using Fitro Force Plate and included the rate of force development test (RFD, 0-200 ms), the maximal isometric strength of lower extremities in various angles of knee joint test (ISOmax) and the diagnostic set for deep squat. ISOmax and RFD were tested in three positions of knee joints (140˚, 90˚ and 50˚), based on the recommendations of Fehér (2006), Tihanyi (1998) and Vanderka et al. (2012). Posture and body segments of the participants were not corrected. In case of RFD test, the subjects were instructed to produce maximal force as fast as possible (lasting 2"). In case of ISOmax test they were instructed to produce maximal force with maximal effort (lasting 5").

External resistance of this diagnostic set was increasing until the highest average power output was reached. Concentric phase of the movement was evaluated. Fitro Dyne Premium was used for the purposes of this test and the posture and body segments of the participants were not corrected. The eccentric phase of the movement was performed at individual pace and the emphasis was put on proper technique of the countermovement. The concentric phase was carried out with maximal effort.

Nonparametric Wilcoxon T-test was used to compare the differences between the two related groups ($\alpha = 0.01$; $\alpha = 0.05$).

Results 2

The biggest increments of isometric force (Δ 89.45 N) were found in the position 50˚, whereas the smallest increments (Δ 45.63 N) were registered in the position 140˚, as shown in figure 2. Statistically significant differences between the initial and final tests were found only in the position of knee joint 50˚ and 90˚.

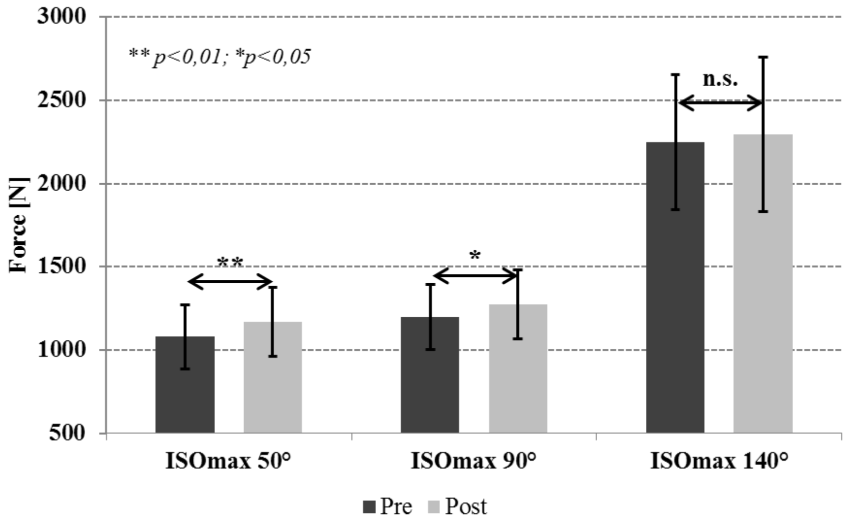

Figure 2

Average (SD) increments of maximal isometric force (ISOmax), tested in three positions of knee joints (140˚, 90˚ and 50˚)

The biggest increments of the rate of force development (Δ 0.47 $N.ms^{-1}$) occurred in the position 90˚. Similar results were obtained in the position 50˚ (Δ 0.42 $N.ms^{-1}$) and the smallest increments in the rate of force development (Δ 0.17 $N.ms^{-1}$) were registered in the position 140˚, as shown in figure 3. Statistically significant differences between the initial and final tests were found in two positions of knee joint: 50˚ and 90˚.

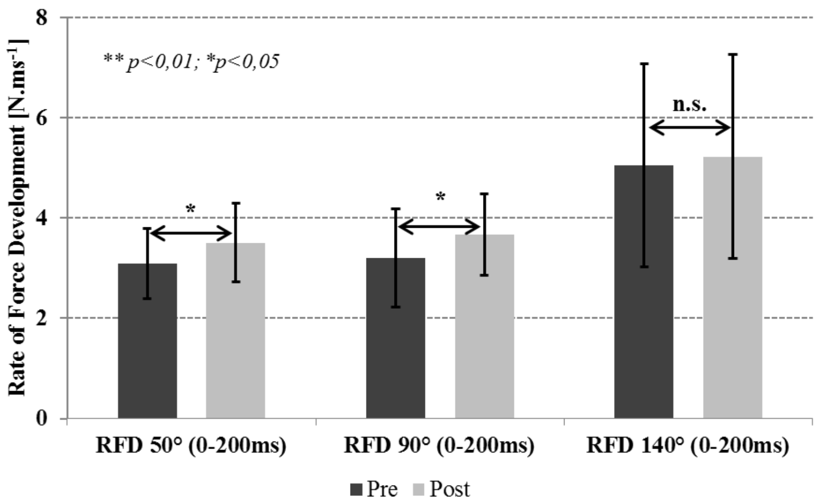

Figure 3

Average (SD) increments of rate of force development (RFD), tested in three positions of knee joints (140˚, 90˚ and 50˚)

Biomechanical parameters at maximal mean power in a diagnostic set (Pmax) show increase in power (27.5 W), weight (7.6 kg) and velocity of movement (2 $cm.s^{-1}$). The range of movement during initial measurements was bigger by 2.1 cm. However, none of the changes were statistically significant.

We analysed biomechanical parameters of the whole diagnostic set as well and found following increments: 38.8 W in power output, 5.7 $cm.s^{-1}$ in the pace of the movement and 3.2 cm in the range of movement. Mean power output and mean pace of movement differed significantly ($p < 0.01$) compared to the initial tests, as shown in figure 4. The significance of the difference between initial and final measurements of the range of motion was only close to the 5 % level.

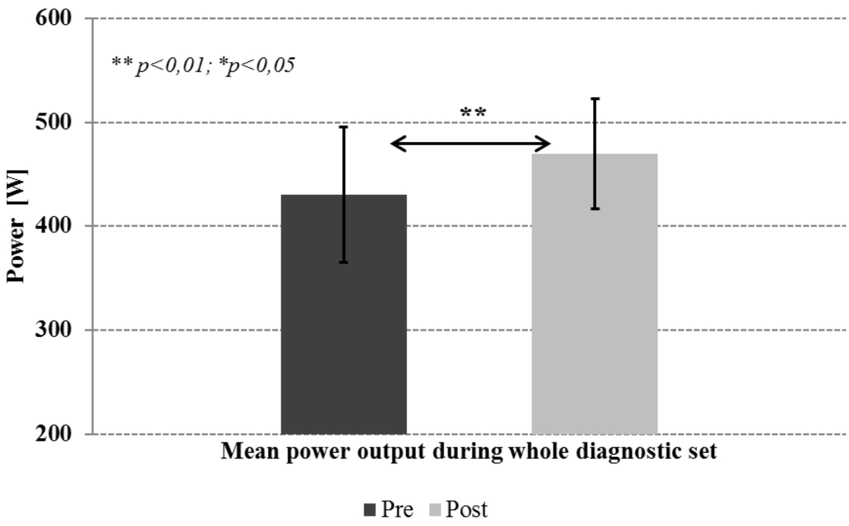

Figure 4

Average (SD) increments of mean power output during whole diagnostic set of deep squat

Discussion 2

The effect of short-term training programme was more pronounced in exercises performed with larger knee flexion (50˚, 90˚). We hypothesise that more experience with particular range of motion lead to minor improvements of ISOmax and $RFD_{0\text{-}200ms}$. Changes in the selected parameters were more pronounced when we compared the diagnostic sets, opposite to the evaluation of maximal power output. Therefore we assume that the changes which occurred after completing the training programme were related only to a particular part of the diagnostic set.

Conclusions

At first it is necessary to point out that the presented results are valid only for the particular subjects. In order to generalise the findings, the study would have to be repeated with more participants.

First part of the paper compared the data of two groups. Differences in the range of motion, mechanical power, relative mechanical power output, isometric force and dynamic force with different external resistances between experienced and inexperienced subjects were found. These results not only proved a higher level of strength performance of experienced subjects, but also created assumptions of better power output and squat-performing experience in the group of experienced participants. We also analysed parameters of maximal isometric force in deep squat and maximal value of force curve in dynamic muscular mode. Differences between the absolute values of $Fmax_{BW+(0\text{-}100\%)}$ and the values of $ISOmax_{50^{\circ}}$ between the groups show the tendency of changes in the variations of differences between the groups. The difference in variations between the groups increases from the resistance of 50 % of body weight. This tendency is statistically significant ($p < 0.05$) in cases when the resistance represented +75 and +100 % of body weight. These weights caused more pronounced differences also between other strength parameters. The explanation can be found in a study by Zatsiorsky & Kraemer (2014), as the interventions with the resistance of 75 and 100 % of body weight led to inverse myotatic reflex through the activation of Golgi receptors in the group of inexperienced subjects. This did not happen in the experienced subjects. The reason could be higher level of the squat-performing experience and the adaptation changes. However this is only a hypothetical explanation. The nonsignificant differences of the variations in tests with lower resistance (+0 %, +25 %, +50 %) confirm the recommendations of using lower external loads for the purpose of strength development, in case the exercise-performing experience is absent.

The second part was devoted to monitoring the impact of short-term training programme of deep squat on the parameters of strength performance (without any intention of strength development). We examined the possibility of affecting the level of force through practising and improving the selected exercise. We wanted to point out that the alternative means of improving the muscle force. The tests of the rate of force development ($RFD_{0\text{-}200ms}$) and the maximum isometric force (ISOmax) at various angles of knee joint (50˚, 90˚, 140˚) show that the training microcycle on RFD and ISOmax has a more pronounced effect on higher knee angles (deep squat and half squat). The evaluation of basic biomechanical parameters at maximal mean power in a diagnostic set DS (Pmax) did not confirm any significance of the changes. We assume that the training programme did not last long enough to significantly increase the maximal power output. However, the evaluation of the whole diagnostic set evolved different conclusions. Based on those results we conclude that the differences in mean power output in the entire DS between initial and final tests were significant, confirming a potential for significant increments. The important finding to underline is that changes in the selected parameters were more pronounced when the entire diagnostic sets was compared, opposite to the results of parameters at the maximum power output (Pmax). Based on these results we assume that the changes which occurred after completing the training programme involved only a selected part of the diagnostic set (mostly at lower weights). Based on the results we can conclude that short-term training programme of deep squat practise (without any intention of improving strength) has positive effect on selected strength parameters. The results of the paper suggest the importance of technical preparation for the prevention of injuries (in terms of proper technique) and for the improvement of selected parameters. The quality of acquiring the training means is also an important issue, as it appears to be a significant determinant of modeling the strength training. Comprehensive methodology of strength training assumes perfectly mastered technique of an exercise, which is also a fundamental requirement for the use of this training means in the development of motor skills.

References

1. BUZGÓ, G., A. NOVOSÁD, I. CIHOVÁ, P. KESZEGH, G. SILLÍK & M. TITURUS, 2014. Škola drepu II. - teoretické východiská uplatnenia drepu v pohybovej a kondičnej príprave. In KOLEKTÍV AUTOROV. *Vzpieranie III*. - učebné texty pre trénerov. 1st ed. Bratislava: ICM Agency, pp. 6-14. ISBN 978-80-89257-66-9.
2. FEHÉR, T., 2006. *Olympic weightlifting*. 2nd ed. Budapest: Tamas Strength Sport Libri Publishing House, pp. 307. ISBN 963-06-0139-7.
3. LACZO, E., G. BUZGÓ & M. KOVÁČ, 2012. Ukazovatele intenzity zaťaženia pri komplexných tréningových prostriedkoch vo vzpieraní. In: KOLEKTÍV AUTOROV. *Vzpieranie I. - učebné texty pre trénerov.* 1st ed. Bratislava: ICM Agency, pp. 55-63. ISBN 978-80-89257-56-0.
4. LEHNERT, M., J. NOVOSAD et al., 2010. Síla. In: LEHNERT, M., NOVOSAD, J. et al. *Trénink kondice ve sportu*. Olomouc: Univerzita Palackého v Olomouci, pp.18-50. ISBN 978-80-244-2614-3.
5. NEUMANN, G., A. PFÜTZNER & K. HOTTENROTT, 2007. *Trénink pod kontrolou.* 1st ed. Praha: Grada Publishing. ISBN 80-247-0947-3.

6. SHICKHOFER, P., 2010. Nové metódy diagnostiky a rozvoja silových schopností. In: KOLEKTÍV AUTOROV. *Športová príprava mladých vzpieračov v podmienkach malých štátov*. 1st ed. Bratislava: ICM Agency, pp. 121-129. ISBN 978-80-89257-26-3.
7. TIHANYI, J., 1998. Az izmok élettani és biomechanikai tulajdonságainak változtatási lehetőségei edzéssel. In: *Magyar edző.* 2, pp. 4-10.
8. TIHANYI, J., 1999. Fyziologické a biomechanické základy adaptácie na tréningové zaťaženie. In: *Zborník vedeckých prác katedry atletiky FTVŠ UK.* 3, pp. 3-12. ISBN 80-968252-0-8.
9. VANDERKA, M., 2008. *Silové a rýchlostno-silové schopnosti v kondičnej príprave športovcov*. 1st ed. Bratislava: ICM Agency. ISBN 978-80-89257-10-2.
10. VANDERKA, M., 2013. *Silový tréning pre výkon*. Bratislava: Slovenská vedecká spoločnosť pre telesnú výchovu a šport, 1st ed. ISBN 978-80-89075-40-9.
11. VANDERKA, M. & T. KAMPMILLER, 2012. Silové schopnosti a ich rozvoj. In: KAMPMILLER et al. *Teória športu a didaktika športového tréningu.* Bratislava: ICM Agency, 1st ed. pp. 113-156. ISBN 978-80 89257-48-5.
12. VANDERKA, M., D. OLASZ & K. LONGOVÁ, 2012. Parametre sily pri cvičení drep v závislosti od veľkosti pokrčenia v kolennom kĺbe. In: KOLEKTÍV AUTOROV. *Vzpieranie I. - učebné texty pre trénerov.* 1st ed. Bratislava: ICM Agency, pp. 46-54. ISBN 978-80-89257-56-0.
13. ZATSIORSKY, V. M. & V. J. KRAEMER, 2006. *Science and Practice of Strength Training*. 2nd ed. Illinois: Human Kinetics. ISBN 978-0-7360-5628-1.
14. ZATSIORSKY, V. M. & V. J. KRAEMER, 2014. *Silový trénink.* Praxe a věda. 1st ed. Praha: Mladá fronta, Edice Českého olympijského výboru. ISBN 978-80-204-3261-2.