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Research article

THE INFLUENCE OF LIFTING STRAPS ON ISOMETRIC BACK EXTENSOR MUSCLE STRENGTH MECHANICAL CARACTHERISTICS: A STUDY OF POWERLIFTERS

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Abstract. *The aim of this study was to investigate how lifting straps affect isometric back extensors muscle strength. The participants were divided according to gender and training level: trained – powerlifters (n = 17) and control – a specifically non-trained group (n = 24). For the purposes of this study, the maximum voluntary contraction of the back extensors was measured in isometric conditions in the isometric back extension exercise. After a 5-minute standard and specific warm-up, the participants had three trials each with lifting straps and without lifting straps, with a break of 2 minutes between trials. They were given the verbal instruction "pull as hard and fast as possible" and hold for 2 to 3 seconds. Repeated measures ANOVA showed a general statistically significant difference (p<0.05) between testing procedures (classical and straps). A paired samples t-test was used to determine differences between maximal and explosive strength variables. Then, the percentage difference (Δ) of all variables (F_{max} - maximal force, RFD_{max} - maximal rate of force development, tF_{max} - time needed to reach maximal force, $tRFD_{max}$ - time for maximal rate of force development) was calculated using the formula: $F_{max\_\Delta} = ((F_{max\_straps} - F_{max\_class}) / F_{max\_class}) *100$. Differences in the maximum isometric back extension force (F_{max}) were found in both groups (powerlifter males - p = 0.004, females - p = 0.019 and control group males - p = 0.018, females – p = 0.001), while differences in tF_{max} were observed only in the control group (males – p = 0.001 and females - p = 0.000). The results showed that lifting straps have a positive effect in measuring supra-maximal isometric strength (averaged enhancement was 15.93±4.58% regardless of gender and training status), and can potentially be used in a methodological sense to determine the objective values*

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of the biological contractile potential in terms of maximum strength, in pulling type of exercises that include a hand grip (the deadlift, lat pull down, mid-thigh pull test).

Key words: *resistance training, rate of force development, testing*

INTRODUCTION

The deadlift, along with the bench press and squat, is a primary component of powerlifting competitions (Fleck and Kraemer, 2004). It is a multi-joint exercise, where the lifter lifts the barbell from the floor performing a hip, knee, and ankle extension until the torso is fully erect and subsequently eccentrically lowered to the floor, and it is used in many modalities of training (Swinton et al., 2011; Haff and Triplett, 2015), as such, it is critical for strength development (Bird and Barrington-Higgs, 2010). Although high loads can be used in the deadlift, the lifter's ability to handle the bar, through grip strength, is often a limiting factor for the amount of weight that can be lifted (Garhammer, 1993).

The study of muscle force as a motor ability in sports has grown dramatically over the years (Stankovic et al., 2021). Muscle force, or muscle strength is an ability that can directly affect the sport result (powerlifting, weightlifting), or indirectly (athletics, sports game) using strength training, which has been shown to lead to an increase in the force per unit CSA of the muscle. This effect has been attributed either to an increase in the neural drive (Moritani & de Vries, 1979; Hakkinen & Komi, 1983; Narici et al., 1989) or to an actual increase in muscle-specific tension due to a denser packing of muscle filaments, which might account for the observed increase in muscle radiological density (Jones and Rutherford, 1987).

Muscle strength testing has been the most often applied approach in testing muscle function in general, as well as functional movement abilities (Abernethy et al., 1995; Jaric, 2002). Muscle strength can be tested by isotonic or isometric tests. The phenomenon of isometric muscle force (IMF) can be estimated in different ways (Marković et al., 2018). Recently, researchers and practitioners have begun using maximal isometric testing to examine the performance and adaptation to training stimuli (Comfort et al., 2019; Haff et al., 1997). The same authors said that, when compared to traditional maximal strength assessments (i.e., RM protocols), isometric testing is considered potentially safer due to biomechanical simplicity, reduced fatigue, and improved time-efficiency. Comfort et al. (2019) are using the isometric mid-thigh pull (IMTP), which is a multi-joint isometric test that has been previously used extensively in research. The IMTP consists of participants pulling against an immovable bar located at a position that mimics the second pull position of the clean exercise, and it allows the assessment of peak force (PF), time-specific force values, and rate of force development (RFD) (Comfort et al., 2015; Dos Santos et al., 2017; Haff et al., 2005; 2015).

When the deadlift is used, the strength of the forearm muscles is a very important factor. Therefore, to reduce fatigue of the forearm muscles during the deadlift exercise, many strategies have been suggested, such as the use of an inverted grip, alteration of bar thickness, magnesium powder, and use of lifting straps (Ratames et al., 2007; Beggs, 2011). With lifting straps, the limitations due to grip strength become less pronounced and, theoretically, an associated load increase would promote greater activation of the targeted muscles (Rimmer, 2001). Coswing et al. (2015) showed greater force using the straps during the deadlift, while Trahey et al. (2023) showed that participants that were using straps could perform more repetitions.

While this was done in a standard deadlift with a barbell, there is no research that shows how lifting straps affects classical isometric deadlift (IDL) testing and how influence in mechanical muscle strength characteristics, as a one of the standard tests used in sports science practice in laboratory and field testing (Dopsaj et al., 2000; Backham et a., 2012; Marković et al., 2018) which is the purpose of this research.

METHODS

The research was conducted in laboratory conditions at the Faculty of Sports and Physical Education in Belgrade. Data collection was performed by the test-retest method, trial after trial. Testing was done in two different conditions: without and with lifting straps. Body composition was measured using bioelectrical impedance. The contractile characteristics of the muscle strength of the back extensors were measured with a tensiometric dynamometer under conditions of maximal isometric contractions. The study was conducted in accordance with the principles of the Helsinki Declaration, as well as with the approval of the Ethics Committee of the Faculty of Sports and Physical Education of the University of Belgrade (484/2).

Subject sample

The research was conducted on a total sample of 41 healthy adults. The participants were divided according to gender and training level: trained - powerlifters (n=17) and control – a specifically non-trained group (n=24). Basic descriptive characteristics of the group of powerlifters (male, n=9 and female, n=8), as well as the control group, consisted of the students of Faculty of Sports and Physical Education (male, n=12 and female, n=12) are shown in Table 1.

Testing procedure

Body height was measured with an anthropometer using a standardized procedure (Dopsaj et al., 2020). Electrical bioimpedance analysis (BIA, InBody 720) described in earlier measurements was used to assess body composition (Bankovic et al., 2018). For the purposes of this study, the maximum voluntary contraction of the back extensors was measured in isometric conditions during the isometric back extension exercise. After the 5 minutes of a standard and specific warm-up exercises, the participants had three trials each with lifting straps and without lifting straps, with a break of 2 minutes between trails. The participants were given the verbal instruction “pull as hard and fast as possible” and hold for 2 to 3 seconds. Figures 1 and 2 show the lifting straps and body position during isometric back extension testing. The test was conducted under laboratory conditions in the methodological research laboratory at the Faculty of Sports and Physical Education. The testing was conducted according to the previously established procedure and equipment (All4gym d.o.o., Serbia) under conditions of maximal isometric contractions (Dopsaj et al., 2019; Dopsaj et al., 2022).

Fig. 1 Lifting straps

Fig. 2 Body position during IDL testing

Variables

The following variables (12) was used in study as well:

Isometric back extension measure in classical test conditions:

1. F_{max_class} – maximal isometric back extension force measured in classic test conditions, expressed in Newtons (N);
2. RFD_{max_class} – maximal rate force of development measured in classic test conditions, expressed in Newtons per second (N/s);
3. tF_{max_class} – time needed to reach maximal isometric back extension force measured in classic test conditions, expressed in seconds (s);
4. $tRFD_{max\_class}$ – time needed to reach maximal rate force of development measured in classic test conditions, expressed in seconds (s);

Isometric back extension was measured with lifting straps in test conditions:

1. F_{max_straps} – maximal isometric back extension force measured in classic test conditions, expressed in Newtons (N);
2. RFD_{max_straps} – maximal rate force of development measured in classic test conditions, expressed in Newtons per second (N/s);
3. tF_{max_straps} – time needed to reach maximal isometric back extension force measured in classic test conditions, expressed in seconds (s);
4. $tRFD_{max\_straps}$ the time needed to reach maximal rate force of development measured in straps test conditions, expressed in seconds (s);

To determine the percentage difference between two measurements (with and without lifting straps) the following variables were used:

1. F_{max_Δ} – the difference between F_{max_straps} and F_{max_class} expressed in percentages (%);
2. RFD_{max_Δ} – the difference between RFD_{max_straps} and RFD_{max_class} expressed in percentages (%);
3. tF_{max_Δ} – the difference between tF_{max_straps} and tF_{max_class} expressed in percentages (%);
4. $tRFD_{max\_\Delta}$ – the difference between RFD_{max_straps} and RFD_{max_class} expressed in percentages (%);

Statistical analysis

For the basic characteristics of the participants, the measure of central tendency was used – average (mean) and measure of dispersion – standard deviation (SD). The t-test for paired samples was used to determine the differences between the maximum and explosive strength variables (F_{max} and RFD_{max}), as well as for the time variables (tF_{max} and $tRFD_{max}$). Repeated measures ANOVA was used to determine if there was an overall statistically significant difference. Then, the percentage difference (Δ) of all variables (F_{max_Δ}, RFD_{max_Δ}, tF_{max_Δ}, $tRFD_{max\_\Delta}$) was calculated using the formula (Dopsaj et al., 2022):

$$F_{max\_delta} = \frac{(F_{max\_straps} - F_{max\_delta})}{F_{max\ class}} \times 100$$

RESULTS

The results of the ANOVA showed a general statistically significant difference between testing procedures (classical and straps) regardless of the participant group and gender (powerlifters and control, male and female – powerlifter males classic vs straps F_{ANOVA}= 49.78, p=0.000; powerlifter females classic vs straps F_{ANOVA}=93.12, p=0.000; control group males classic vs straps F_{ANOVA}=58.20, p=0.000; control group females classic vs straps F_{ANOVA}=165.09, p=0.000). Table 1 shows the basic descriptive indicators of the studied variables.

Table 1 Basic descriptive results regarding the sample of participants characteristic titles

Variables	Powerlifters Male	Powerlifters Female	Control group Male	Control group Female
Age	22.7 ± 3.1	25.5 ± 5.3	24.2 ± 2.5	22.6 ± 1.7
BH (cm)	182.1 ± 4.8	170.5 ± 6.8	184.2 ± 6.8	169.1 ± 4.7
BM (kg)	86.6 ±10.7	66.2 ± 9.7	82.5 ± 13.3	61.8 ± 6.3
BMI (kg/m^2)	26.1 ± 2.4	22.7 ± 2.9	24.2 ± 2.8	21.6 ± 1.4
PBF (%)	11.7 ± 4.3	15.7 ± 6.2	11 ± 3.3	20.7 ± 8.7
PSMM (%)	51.04± 2.7	47.7 ± 4.2	50.96 ± 2	45.6 ± 2.1
Tr/week (n)	6.9 ± 2.1	5.9 ± 0.8	3.3 ± 1	3.8 ± 1.1
TDP_session (min)	93.3 ±23.5	82.5 ±21.2	85 ± 17.3	68.2 ±14

Tr/week (n) – number of training sessions per week; TDP_session (min) – average training duration per session; BH (cm) – body height; BM (kg) – body mass; BMI (kg/m^2) – Body Mass Index; PBF(%) – percentage of body fat index; PSMM (%) – percentage of skeletal muscle mass

Table 2 presents the differences between classic contractions and the use of lifting straps. The results show differences between male (p=0.00) and female (p=0.02) powerlifters only in the F_{max} variable. Differences also exist in the control group for both females in the Fmax (p=0.00) and tF_{max} (p=0.00) variables and males in the F_{max} (p=0.02) and tF_{max} (p=0.00) variables.

Table 2 Differences between classic contractions and lifting straps in the following variables

Group	Powerlifters				Control group			
Gender	Males		Females		Males		Females	
	t	p	t	p	t	p	t	p
F_{max_class} vs F_{max_straps}	-3.93	0.004*	-3.04	0.019*	-2.77	0.018*	-4.85	0.001*
RFD_{max_class}vs RFD_{max_straps}	-0.56	0.588	-1.48	0.182	1.40	0.189	-1.33	0.209
tF_{max_class} vs tF_{max_straps}	-1.11	0.300	-0.72	0.497	-4.20	0.001*	-5.48	0.000*
$tRFD_{max\_clas}$ vs $tRFD_{max\_stras}$	-0.58	0.152	-0.42	0.690	0.60	0.561	-0.07	0.944

Significant difference * $p<0.05$

Figure 1 shows that the highest percentage difference is present in the female controls, while the smallest percentage differences are present in female powerlifters.

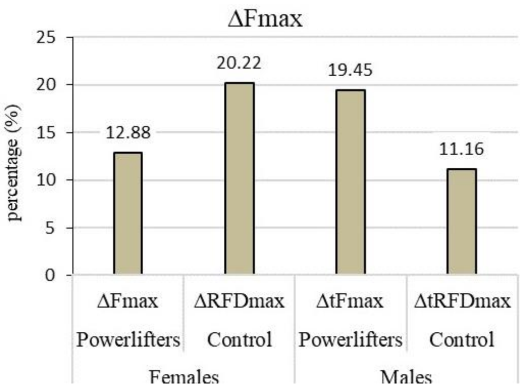

Fig. 1 Percentage differences in the variable (ΔF_{max}) relative to gender and group

Figure 2 shows that the highest percentage difference is present in female powerlifters, while the smallest percentage differences are present in the male control group.

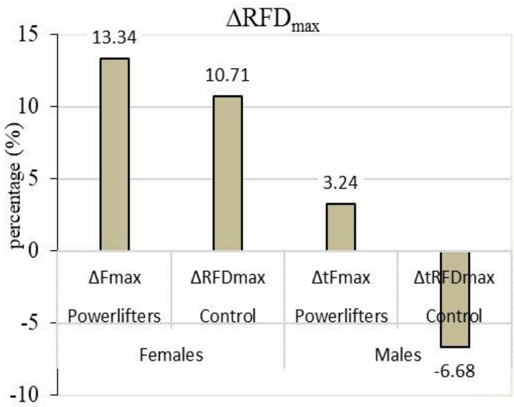

Fig. 2 Percentage differences in the variable (ΔRFD_{max}) relative to gender and group

Figure 3 shows that the highest percentage difference is present in the female control group, while the smallest percentage differences are present in male powerlifters.

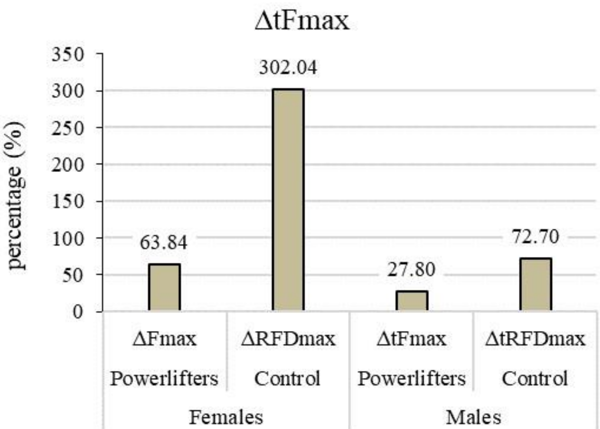

Fig. 3 Percentage differences in the variable (ΔtF_{max}) relative to gender and group

Figure 4 shows that the highest percentage difference is present in male powerlifters, while the smallest percentage differences are present in the female control group.

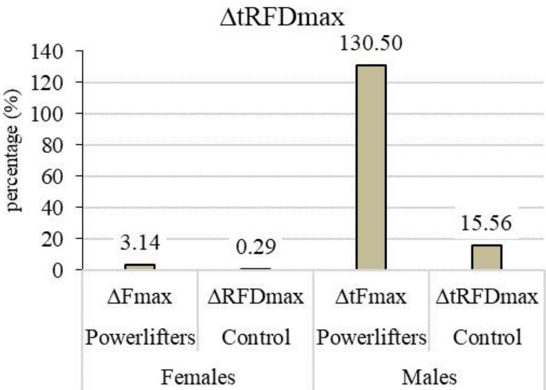

Fig. 4 Percentage differences in the variable ($\Delta tRFD_{max}$) relative to gender and group

DISSCUSION

This study aimed to evaluate the effects of lifting straps on isometric strength muscle testing realized on the isometric back extension test. Differences in F_{max} were found in both groups, while differences in the tFmax were observed only in the control group (Table 2).

The variable F_{max_straps} was significantly greater than F_{max_class} in the powerlifters group: males (F_{max_Δ}=19.45%; p=0.004) and females (F_{max_Δ}=12.87%; p=0.019) and the control group: males ($F_{max\_\ \Delta}$=11.16%; p=0.018) and females (F_{max_Δ}=20.21%; p=0.001, Table 2,

Figure 1, respectively). Coswig et al. (2015) reported similar results in their study in which participants lifted more weight in the deadlift exercise when they were using straps (180±14.8 kg) in comparison to when they were not (151±23 kg). Straps increased the amount of weight lifted by 19.20%. In the study of Elkins (2020) male participants with lifting straps produced more force (2102.3±506.2N) than without straps (1468.6±286N) in the mid-thigh pull test, which is 43.1% greater force output. Also, the female participants, when strapped (1105±294.7N), produced a 17.5% greater force in comparison to when they do not use straps (940.6±155.7N). The findings of both mentioned studies are in line with results of our study. The most possible reason for the presented results may be explained by the mechanical and neural component of muscle force production (Gollhofer, 2008). Lifting straps additionally increase friction between hand skin and the bar, just as they decrease the pain of the skin also created as a product of friction, during the maximum isometric pull (Pratt et al., 2020).

Nominally higher values of F_{max_Δ} in males from the powerlifter group compared to males from the control group of participants were found (19.45% vs. 11.16%, Figure 1). Trivedi et al. (2022) measured the average powerlifter grip strength of 618.03N and Dopsaj et al. (2019) measured 517.1N as the average hand grip strength of male students, which is only 16.4% less than powerlifters, so we can conclude that the difference is not as close as a difference in the isometric back extension test. So our results can be explained by a greater difference in force production between the back extension test and hand grip strength in powerlifters compared to the control group. Therefore, grip strength is a bigger limiting factor for powerlifters, so using lifting straps can be more beneficial for them.

Nominally higher values of F_{max_Δ} in females from the control group compared to females from the powerlifters group were found (20.21% vs. 12.87%). These results can be explained by the low level of grip strength of the female population that is not specifically trained. Massy-Westropp et al. (2011) reported mean values of 294.3N for the right and 274.68N for the left hand, which is 37% lower compared to the male participants. Dopsaj et al. (2019) measured 279.1N for the dominant hand and 258.5 for the non-dominant hand in female students, which is 46.3% lower than for the male participants. Therefore, females that are not specifically trained have a much greater ability to produce force in the isometric back extension test than they can hold with their hands, so they can benefit more from using lifting straps, than specifically trained females who have practiced lifting without straps.

Therefore, the results showed that the influence of lifting straps, as a coaching methodological tool, is much greater in control group of females than in specifically trained group of females. Most likely, this phenomenon can be explained by the lower training level of the control group in the form of maximal contractile potentials in isometric back extension testing (less experience in lifting technique, less experience of using lifting straps, less experience in maximal voluntary contractions, motivation, etc.). So by adding lifting straps, the contractile potential increases to a much greater extent than in powerlifters. In other words, due to experience and training level, during the basic performance of the test, the female powerlifters were able to increase the level of contractile potential during the maximum isometric effort, and therefore the addition of the lifting straps had relatively smaller additional effect on improving the results.

The effects of lifting straps on RFD_{max} were not significant for either group ($p>0.05$, Table 2). These results are in agreement with the results of Hori et al. (2010), who found that peak vertical RFD was not significantly different between the lifting straps conditions (16011.7±8301.5 N/sec) and no lifting straps conditions (16012.3±7341.5

N/sec) ($p>0.05$). The explanation can be found in the fact that neither the powerlifters nor the control group were trained with a focus on explosiveness. The goal of powerlifters training is to produce as much force as possible, i.e. to lift as much weight as possible, so they have a pattern of force development that does not focus on reaching the maximum force in the shortest amount of time (IPF, 2023).

Time variables (tF_{max} and tRFD) show differences only in the control group for tF_{max}. Participants from the control group needed less time to reach F_{max} when using straps (male $p=0.001$; female $p<0.001$, Table 2). The most possible reason for these results is that the control group participants do not have an established pattern of force production, so as soon as the conditions change, their pattern changes, concerning reducing time needed for F_{max}, more significantly compared to powerlifters.

The results of this study suggest that the use of lifting straps improves performance in terms of achieving greater maximal strength and explosiveness. Therefore, lifting straps could be used in the training of athletes and recreational lifters, considering that grip strength is a limiting factor, and it could be beneficial in adding more reps to a performance (Trahey et al., 2023). A limitation of this study could be familiarity with isometric strength testing. In this regard, an additional day of familiarization would give the participants the opportunity to practice the test procedure.

CONCLUSION

The use of lifting straps allows the participants to realize a statistically significantly higher level of maximum force compared to the classic testing situation, i.e. testing without them, in an isometric back extension test, regardless of the training level or sex (averaged enhancement was: 15.93±4.58%, or from 11.16% for the control male to 20.22% for the control female, and for 12.88% for the female to 19.45% for the male powerlifters). It was also found that lifting straps have no influence on RFD_{max} in the same test. The results of the study showed that for specifically trained participants (powerlifters), straps do not affect the time parameters of the realization of the isometric contraction, while for non-specifically trained participants (the control group) it leads to a reduction of the time to reach F_{max}. The results showed that lifting straps have a positive effect in achievement supra-maximal isometric strength, considering that strength of the forearm muscles is a very important factor, and can potentially be used in a methodological sense to determine the so-called objective values of the biological contractile potential in terms of additional maximum strength level, in pulling type of exercises that include a hand grip (the deadlift, lat pull down, mid-thigh pull test).

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UTICAJ GURTNI NA MEHANIČKE KARAKTERISTIKE IZOMETRIJSKE SNAGE MIŠIĆA TOKOM MRTVOG DIZANJA: STUDIJA NA POWERLIFTERIMA

Cilj ovog istraživanja bio je da se ispita kako gurtne utiču na izometrijsku snagu mišića tokom mrtvog dizanja. Ispitanici su podeljeni prema polu i nivou treninga: trenirani – powerlifteri (n = 17) i kontrolna grupa – specifično netrenirani pojedinci (n = 24). Maksimalna voljna kontrakcija mišića opružača leđa merena je u izometrijskim uslovima u vežbi mrtvog dizanja. Nakon standardnih i specifičnih vežbi zagrevanja u trajanju od 5 minuta, ispitanici su izveli po tri pokušaja sa gurtnama i bez gurtni, uz pauzu od 2 minuta između pokušaja. Verbalne instrukcije su bile: „Povuci maksimalno jako i maksimalno brzo" i zadrži 2 - 3 sekunde. ANOVA za ponovljena merenja pokazala je statistički značajnu razliku (p<0,05) između testiranja (klasično i sa gurtnama). T-test za zavisne uzorke korišćen je za utvrđivanje razlika između maksimalnih i eksplozivnih varijabli sile. Procentualna razlika (Δ) svih varijabli (F_{max} – maksimalna sila, BRS_{max} – maksimalna brzina razvoja sile, tF_{max} – vreme potrebno za dostizanje maksimalne sile, $tBRS_{max}$ – vreme postizanja maksimalne brzine razvoja sile), izračunata je pomoću formule: $F_{max\Delta}=((F_{maxgurtne}-F_{maxklasično})/F_{maxklasično})*100$. Razlike u maksimalnoj izometrijskoj sili mrtvog dizanja (F_{max}) pronađene su u obe grupe (powerlifteri muškarci – p = 0,004, žene – p = 0,019 i kontrolna grupa muškarci – p = 0,018, žene – p = 0,001), dok su razlike u tF_{max} uočene samo u kontrolnoj grupi (muškarci – p = 0,001 i žene – p = 0,000). Rezultati su pokazali da gurtne imaju pozitivan efekat na merenje supramaksimalne izometrijske snage (prosečno povećanje iznosilo je 15,93±4,58%, bez obzira na pol i nivo treninga) i mogu se potencijalno koristiti u metodološkom smislu za određivanje objektivnih vrednosti biološkog kontraktilnog potencijala u smislu maksimalne snage, kod vežbi vučenja koje zahtevaju jačinu hvata (mrtvo dizanje, vučenje na lat mašini, "mid-thigh pull test").

Ključne reči: *trening snage, brzina razvoja sile, testiranje*