Journal of Physical Education and Sport ® (JPES), Vol.20 (5), Art 352, pp. 2580 - 2585, 2020
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Development of specific training load in boxing

ŠIŠKA ĽUBOSLAV[1], HUBINÁK ANDREJ[2], KRŠKA PETER[3], BROĎÁNI JAROSLAV[4,]
[1,2,3,] Department of physical education and sport, Catholic University in Ružomberok, SLOVAKIA,
[4,] Department of physical education and sport, Constantine the Philosopher University in Nitra, SLOVAKIA

Published online: September 30, 2020
(Accepted for publication: September 22, 2020)
DOI:10.7752/jpes.2020.05352

Abstract
Motor tests to verify the performance of athletes are an integral part of long-term sports training. The aim was to design a specific short-interval training load that could be used as a diagnostic testing tool, develop the relevant assessment methodology and identify its immediate effects on motor performance. The research set consisted of 45 subjects divided into three groups of 15 (women, men, boxers). The load exercise was designed as a physical equivalent of a boxing match with the duration of 3x3 min., and it consisted of repetitive power-speed sequences: a combination of two push-ups and one maximum-effort movement. The duration of one sequence was approximately 5 seconds. We counted the number of sequences during the 3x3 min. load. During the sequence, we measured the duration of the hand contact with the pad in the first and second push-up, and the time it took the subject to run around a dummy, the sum of which represents the sequence intensity. During the load, we also evaluated the drop in performance and gave the overall test score. In our best subject, the number of sequences decreased from 29 in the first round to 25 in the third round. The sequence intensity decreased from 3.52 ± 0.28s to 3.93 ± 0.28s $p < 0.01$. The total score decreased from 8.24 to 6.45 points. The performance drop varied from 9.5% to 20.5%. When evaluating the entire set, the boxers achieved the highest number of sequences $p < 0.01$ and they also exhibited a decrease in performance between the rounds $p < 0.01$. In view of sequence intensity, males and boxers achieved similar results $p > 0.05$, and no reduction of performance $p > 0.05$ was recorded between the rounds. The best total score was achieved by the boxers $p < 0.01$; and they also showed a decrease in performance between the rounds $p < 0.01$. The designed load exercise can serve as a useful training means for the development of special endurance, but also diagnostics.
Key words: boxing, specific load, diagnostics, intensity, performance drop

Introduction

Combat sports are gaining more and more popularity. High sports performance requires an effective adjustment of the training process, which implies a significant knowledge of the structure of sports performance. There is plenty of relevant information in this area, and reaction speed, explosive strength and special endurance are understood as the limiting factors in combat sports. Boxing can be characterized as an acyclic sport, in which the high-intensity sequences alternate with lower-intensity sequences in an approximate ratio of 1:1 to 1:2, with the average duration of the high-intensity sequence being 1 to 2 seconds up to a maximum of 5 seconds(Šiška, 2016). The physiological response of the human body to the in-match, sparing or training load is denominated by the lactate levels ranging from 9 to 14 mmol and heart rate above 90% of the maximum(Ghosh, 2010; Arsenau, 2011; Oeurgui, 2014; Hanon, 2015). Percentage distribution is according Davis (2014) 77% aerobic coverage, 19% creatine phosphate and 4% anaerobic coverage. In simple terms, boxing is typical for a high-intensity and short-interval physical load of an explosive nature, represented by a mixture of punches, evasive maneuvers, defensivetechniques and moving around the ring.

The intervals repeat throughout the match, with unstable and relative intervals of rest between them. In terms of intensity, it is important to avoid significant drops in performance (fatigue), which is expressed by the level of special endurance. This must be taken into account when creating the physical preparation program. Numerous authors proposed universal motor programs within the duration of a competitive boxing match with the aim to develop specific skills given the nature of endurance in boxing. These motor programs used either the own weight of the boxer, additional weights, or specific exercises such as punches, dodging etc.(Hatfield, 2003; Nunan, 2006; Oeurgui, 2015; Thomson, 2017). Push-ups, Burpees etc. are a frequently used group of exercises in the training process, and they rely on the own weight of the boxer. In terms of biomechanics, triceps brachii and anterior deltoid are mainly involved(Cogley, 2005; Contreras, 2012). When taking a closer look at the actual punch, we can find many similarities with a push-up because the EMG analysis confirmed the involvement of the entire muscle loop ranging from Gastrocnemius, through Biceps and Rectus Femoris, followed by Anterior Deltoid, Upper Trapezius, Biceps and Triceps Brachii, to Flexor Carpi Radialis(Dyson, 2007). The muscles of the upper limb usually include the muscles of arm and triceps(Lockwood, 1997). Filimonov (1985) suggests the

Corresponding Author: . ŠIŠKA ĽUBOSLAV, E-mail: luboslav.siska@ku.sk

following distribution of individual muscle groups in a punch: approx 38.5% is in the stretch shortening cycle of the back foot, 37.5% is accounted for by the torso rotation and 24% stretches the punching arm. Interesting finding is also a dependence between the level of shoulder muscle strength and the number of wins (Tasiopoulos, 2015). Based on the above facts, we see push-ups and their variations in combination, for example, with quick movements often seen in boxing, as appropriate exercises for the development of strength and in the repeat mode endurance too.For example, burpees are often used exercise not only in the training process but also in diagnostics (Podstawski, 2019).In terms of time, one repetition of the modified Burpee takes about 2 to 2.5 seconds(Šiška, 2017), and the contact time of the palms with the pad in a push-up is about 1 second(Šiška, 2018) which is useful in the design of a short-interval load exercise. The aim or our work was to design a specific training load that could be used as a diagnostic test, develop the relevant assessment methodology and identify its immediate effect on motor performance.

Material &Methods

Subjects

The research set consisted of 45 subjects divided into three groups of 15 (Tab. 1). The set of male and female sportsmen was formed by students from the Department of Physical Education and Sports, UKF Nitra. Of the overall number of 30 students of physical education, 23 did sports at a performance level, e.g. sports games (football, basketball, volleyball, hockey), athletics, tennis and others. They reported 2-5 training sessions per week. 7 students did recreational physical activities. The set of boxers consisted of athletes from the clubs BCS Nitra and Probox Nitra, with 3-8 training sessions per week. Each of the boxers participated in at least one competitive match. All participants signed an informed consent form before participation.

Table 1. Characteristics of the groups (mean ± SD).

Group	Age (y)	Body weight (kg)	Body height (cm)	Box experience
women (n =15)	21.67 ± 1.76	62.13 ± 7.46	169.60 ± 7.17	
men (n = 15)	22.27 ± 1.49	74.93 ± 9.88	180.87 ± 8.21	
boxers (n = 15)	19.07 ± 2.52	71.47 ± 13	179.93 ± 8.19	4.13 ± 1.8

Procedures

Before the actual testing, all subjects did the same warm-up exercise, trained the sequence and then repeated it three times. The duration of the specific load was identical to the timing of a boxing match, i.e. 3 x 3 minutes, with a 1 minute break between the rounds, and it was designed as a physical equivalent of the boxing match. It consisted of a repetitive power-speed sequence – a combination of two push-ups and one maximum effort motor exercise. The duration of one sequence was approximately 5 seconds. A 150 cm tall boxing dummy with a base diameter of 60 cm was placed on the ground, accompanied by the FiTRO agility plate next to it (to record the contact duration with the plate and detachment time)(Zemková, 2001). The power-speed sequence began from the standing position. The subject carried out a push-up on straight or slightly bent outstretched arms with one palm on the plate, then stood up, ran sideways around the dummy, and did another push-up on the other side with the other palm on the plate, and finally stood up to complete the sequence. During the entire sequence, the subject's aim was to attain the highest sequence intensity possible and exert maximum effort (Fig. 1). After the second push-up there was a break, with each subject having the freedom to spend it individually depending on his/her current feelings and momentary performance. After the break, another sequence followed on the side where the subject finished his/her previous, i.e. the sideways run around the dummy was performed with the opposite leg. This way, a short-interval high-intensity load was created, which can be quantified by the contact time parameters recorded on the plate.

Figure I. Sequence of execution

The total number of sequences in the 3x3 min load period (S) was counted. During the sequence, we recorded the duration of hand contact with the pad in the first and second push-up (C_1, C_2), and the time to run around the dummy (M), the sum of which represents the intensity of the sequence ($I = C_1+M+C_2$).
Theheart rate duringtheloadwasmeasuredwith a SUUNTO POD chestbelt, and theresultsweredirectlyrecorded in special software everysecond.
Statistical analysis

When presenting the research data, were used the descriptors such as the arithmetic mean (M) and standard deviation (SD). To compare the rounds and groups, we use the ANOVA analysis (one-factor and two-factor with repetition). The confirmation or rejection of the hypotheses is expressed at a 5% and 1% significance level. The performance drop (index of fatigue) is expressed as a percentage difference of the last and first value on the linear trend line with regard to the first value(Šiška, 2017). To arrive at a single digit result of the test, we designed a formula representing the proportion of the count of sequences and their intensity $TS = S / (C_1 + M + C_2)$.

Results

Table 2. Parameter values achieved during the specific load of the individual subjects

Parameter	I. Round	II. Round	III. Round	Overall
number of sequencies (n)	29	25	25	79
first contact time (s)	0.80	0.98	0.98	0.91
movement time (s)	1.87	1.89	1.84	1.87
second contact time (s)	0.85	1.06	1.06	1.02
intensity of sequence (s)	3.52	3.93	3.87	3.80
first linear intensity time (s)	3.19	3.75	3.55	3.42
last linear intensity time (s)	3.85	4.10	4.19	4.10
decrease of performance (%)	20.60	9.45	17.97	19.95
test score (points)	8.24	6.37	6.45	20.76
Heart rate max (bpm)	187	191	193	193

When evaluating the individual subjects, we noted an increase in the first and second push-up contact time between the rounds of $F2,76 = 22.38$; $p < 0.01$ and $F2,76 = 19.63$; $p < 0.01$, and the run time around the dummy did not change $F2,76 = 0.95$; $p > 0.05$. The overall sequence intensity changed $F2,76 = 15.67$; $p < 0.01$ (fig. 2)

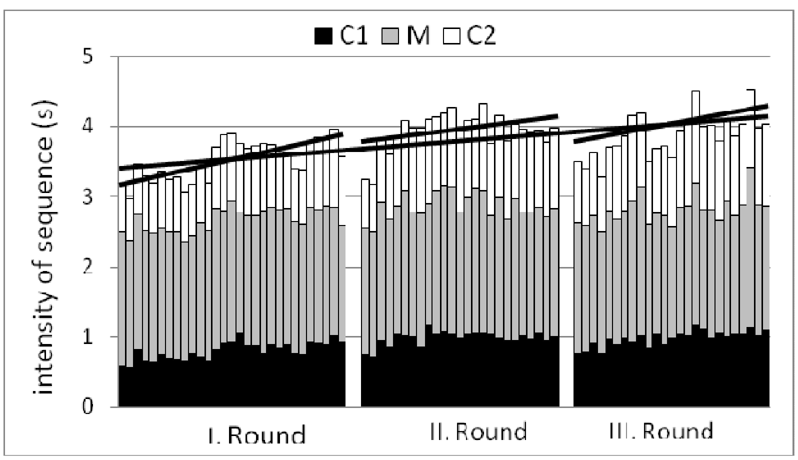

Figure II. Process of intensity sequence and linear trends during specific load of the individual subjects

When evaluating all three groups, boxers achieved best results in number of sequences and palm contact time. Movement time was best in groups of men.

When comparing the number of executed sequences in the individual rounds, we conclude that the groups differed significantly $F2,126 = 27.32$; $p < 0.01$ and we also noted a statistically significant decrease in performance $F2,126 = 10.93$; $p < 0.01$. When comparing the duration of the first push-up in the individual rounds, we conclude that the group of men and boxers achieved similar results $p > 0.05$, the group of women achieved the worst results $F2,126 = 6.72$; $p < 0.01$, and no statistically significant decrease of performance F2,126 = 00:15; $p = 0.85$ was noted. When comparing the duration of the second push-up in the individual rounds, we conclude that the group of men and boxers achieved similar results $p > 0.05$, the group of women achieved the worst results F2,126 = 4.25; p <12:05 and no statistically significant decrease of performance F2,126 = 00:11; $p = 0.89$ was noted. When comparing the run time around the dummy in the individual rounds, we conclude that the groups differed significantly F2,126 10.46; p <0.01 but no statistically significant decrease in performance F2,126 = 10.93; p = 0. 77 was noted. When comparing the overall intensity of the sequence, the group of men and boxers achieved similar results $p > 0.05$, the group of women achieved the worst results F2,126 = 20.51; p <0.01, and no statistically significant decrease in performance F2,126 = 4:31; $p < 0.05$ was noted.

When comparing the final test results for the individual rounds, we conclude that the sets differed significantly F2,126 = 20.51; $_p$ <0.01, and this was also accompanied by a statistically significant decrease in performance F2,126 = 4.31; $_p$ <0.05(tab. 3).

Table 3. The number of sequences, time duration values and test score achieved during a specific load in the individual rounds and groups

Parameter	Group	I. Round	II. Round	III. Round	Overall
	women	17.9±2.70	15.9±3.62	15.3±3.77	49.1±9.40
number of sequencies (n)	men	19.1±2.50	16.9±2.76	15.5±2.50	50.9±5.48
	boxers	22.6±3.04	20.5±2.92	19.7±3.92	62.8±9.21
	women	1.19±0.20	1.12±0.23	1.14±0.28	1.15±0.23
first contact time (s)	men	0.99±0.25	0.99±0.22	1.04±0.25	1.01±0.23
	boxers	0.98±0.18	1±0.17	1.01±0.19	0.99±0.17
	women	2.64±0.32	2.49±0.35	2.46±0.33	2.53±0.28
movement time (s)	men	2.2±0.23	2.21±0.27	2.28±0.28	2.23±0.25
	boxers	2.37±0.33	2.38±0.33	2.36±0.36	2.37±0.32
	women	1.25±0.21	1.17±0.23	1.18±0.24	1.2±0.22
second contact time (s)	men	1.09±0.23	1.07±0.22	1.1±0.25	1.09±0.22
	boxers	1.04±0.21	1.08±0.21	1.11±0.24	1.07±0.21
	women	5.08±0.59	4.78±0.70	4.78±0.79	4.88±0.70
intensity of sequence (s)	men	4.28±0.57	4.27±0.60	4.42±0.71	4.33±0.62
	boxers	4.39±0.58	4.46±0.56	4.48±0.64	4.43±0.58
	women	3.59±0.84	3.43±1.04	3.35±1.13	10.37±2.72
test score (points)	men	4.54±0.89	4.05±0.89	3.61±0.89	12.20±2.37
	boxers	5.28±1.19	4.69±1.05	4.57±1.30	14.54±3.38
	women	178.27±13.26	182.33±11.77	184.87±10.54	184.87±10.54
Heart rate max (bpm)	men	181.00±10.38	183.6±8.83	183.9±10.54	183.9±10.54
	boxers	188.00±8.94	189.87±8.03	191.33±7.17	191.33±7.17

.

Discusion

There were a number of attempts to design a specific load exercise similar to a competitive match, however, none of them were as comprehensive as ours. In our first research, we have shown that the load proposed by us is comparable to a training match in terms of heart rate response(Krška, 2019). The values were in the range of 180-195 pulses. Thompson (2017)presented similar results under the 3x3 min. load from the first to the third round in a range of 180-195 pulses. Oeurgui (2015) in the load specific for kickboxing with the duration of 3x2 min., were recorded the heart rate values ranging from 184 to 190 pulses, which is a level similar to the training match.Nikolaidis (2017), Ghosh (2010), El-Ashker (2018), De-Lira (2013) In sparring or a training match reported the heart rate values of about 190 pulses on average, and a maximum value of up to and over 200 pulses, which is comparable to our research. Our load exercise was designed as a training equivalent to the competitive or training match. Above all, we wanted the load exercise to be usable as a training tool and, where appropriate, as a specific diagnostic tool to test the endurance abilities, as it was designed based on an analysis of performance in boxing(Šiška, 2016). In terms of the time and engaged muscle groups, the power-speed sequence itself meets the performance demands in boxing. Taking the average sequence time of five seconds into account, the sequence is comparable to the longest active phase in a boxing match. When comparing the contact time of the hands with the pad during the push-up, which ranged from 0.6 seconds to 1.5 seconds in the worst cases, and the punch time according toLoturco (2015), Chadli (2014) ranging from 0.4 to 1 second, we arrived at a very similar time range. We did not find any studies that directly deal with the issue of duration of hand contact with the pad in a push-up and the explosive level, however, this parameter is taken into account in the lower limbs and when testing vertical jumps, especially in a repeated exercise. In addition to the kinematic characteristics, one of our future recommendations is to monitor the dynamic characteristics using a dynamometer plate, and the possible relations between them. In view of the results presented byZalleg (2018), Ebben (2011), who reported power requirements in the explosive push-ups and verified their positive effects on the power parameters, especially of the explosive nature, the contact time during a push-up and its development over time appears to be a valid parameter for assessing the strength and endurance preparedness in boxers. This fact, however, must be precisely verified in future investigations. During the load exercise, we measured the count of sequences and the development of its intensity as a measurable of special endurance. In terms of the count of sequences, all sets reported a significant drop between the rounds. This fact would confirm the findings byOeurgui (2014) regarding the drop of high-intensity phases between the rounds during a match. The boxers clearly achieved the best results in this indicator, which was expected. When focusing on the immediate effect of load on the individual time characteristics, we expected a drop in performance between the rounds. The assessment and evaluation of the load results consists of three parameters that signal the overall intensity of the sequence. The push-up duration worsened in men and boxers between the rounds, but not statistically significantly, and an improvement was noted in women. The run time around the dummy did not change significantly between the rounds, and an improvement was noted in women, which is not in line with the findings of other authors. The loss of performance caused by specific load was reported by (Oeurgui, 2015). It was identified through motor tests (vertical jump, Wingate 30s to upper body) carried out before and after the load phase. These arguments, however, are in contradiction toNikolaidis (2017) who reported improved performance in the vertical jump after a 3x3 min. sparing load. The push-up contact times were the best in boxers, however, they did not differ significantly from men who achieved the best time in the run around the dummy, and the overall sequence intensity. The set of men included the students from the Department of Physical Education who are active athletes in many cases, and therefore it is understandable that they can develop an intensity similar to the boxers but fail to maintain it in the long run because they are not adapted to this specific type of load. Even this argument confirms that the load was designed correctly. In our previous research Šiška (2017), we defined fatigue as a linear development of performance under load in equally long segments, and we expressed the percentage of the trend line drop. We also used this methodology in our current research – when evaluation the best subject, we can conclude that the loss of performance or fatigue index was between 9 and 20%. Although the fatigue index was the lowest in the second round, the first linear performance rendered the worst results, and therefore performance appears to be better in the first and third round. Overall, in terms of the fatigue index and/or performance drop, we expect that a higher sequence intensity and lower fatigue index achieved in the test may determine the success of a competitive match. This assumption must be verified by a targeted intervention program during the training cycle. When looking at the individual results, we can also conclude that we achieved the "burn-out rate" in some subjects mainly from the group of men who did a large number of sequences in the first round – comparable to the intensity of the boxers – however, their performance in the subsequent rounds decreased significantly. A similar trend was observed in the weaker boxers. When evaluating the results, one must also focus on the instances when two subjects reached the same number of sequences, and therefore similar break intervals between them, but a significantly lower intensity of the sequence. For this reason, the calculation of the total test score was proposed, and the best results were achieved by the boxers. Overall, however, we conclude that the boxers have reached the most balanced performance results during load especially in the breaks between the sequences because the duration of the breaks did not fluctuate as much as in men and women – here, one break was short, e.g. 2 seconds, but the other was long, e.g. 10 seconds. Our subjective view is that the superior boxers in terms of performance achieved better results both in terms of the intensity and sequence count, and therefore the design of the load exercise appears to be valid to diagnose the specific power-endurance capabilities in boxers.

Conclusions

In conclusion, we add that we managed to design an exercise program that can be used as a training and a diagnostic tool for measuring the specific endurance boxing skills. We quantified the power-speed sequence, and this allows us to track the development of load in real time. Decrease in performance, whether in terms of intensity or number of sequences, maybe in somecases a crucialfactor of thesuccess in a match. These assumptionsneed to bepreciselyverified by targetedapplication of theload to thetrainingprocess.The designed load is essentially very simple and capable of modification in terms of time, and adaptable to other – and not only combat – sports because the power-speed performance in a repetitive endurance mode eventually becomes the limiting factor in most sports. In terms of time management, it can be used at any stage of the training process and training phase as a transfer of the fitness potential into specific physical performance. Thanks to its simplicity, the said power-speed sequence has a great potential to enrich the training process.

References

Arseneau, E., Mekary, S., Leger, L. (2011). VO2 requirements of boxingexercises. *J StrengthCondRes*, 25(2), 348-359.

Ashker, S.,Chaabene , H., Negra , Y., Prieske , O., Granacher, U.(2018). Cardio-RespiratoryEndurance

ResponsesFollowing a Simulated 3x3MinutesAmateurBoxingContest in Elite LevelBoxers. *Sports*, 6(4), 119.

Cogley,R.M., Archambault, T.A., Fibeger,J.F., Koverman,M.M.,Youdas,J.W., Hollman,J.H. (2005). Comparisonofmuscleactivationusingvarioushandpositionsduringthepush-upexercise. *J Strength CondRes*, 19, 628–633.

Contreras,B., Schoenfeld, B., Mike, J., Tiryaki-Sonmez, G., Cronin, J., Vaino, E.(2012). TheBiomechanics of thePush-up: ImplicationsforResistanceTrainingPrograms*Strength and conditioningjournal*, 34(5), 41-46.

Davis,P.,Leithäuser, R.M.,Beneke, R. (2014). TheEnergetics of Semicontact 3 x 2-min AmateurBoxing. In *International Journal of SportsPhysiology and Performance*, 9(2), 233 -239.

De lira,B.,Pena,L.P., Vancini, R.L., Fachina, R.G., Almeida, A.A., Andrade, M.S., Silva, A.C. (2012). Heart rate responseduring a simulated Olympic boxing match is predominantly above ventilatory threshold 2: a cross sectional study. *Journal of Sports Medicine*, 4, 175–182.

Dyson, R., Smith, M., Martin, Ch., Fenn, L.(2007). MuscleRecruitmentDuringRearhandPunchesDelivered at MaximalForce and Speed by AmateurBoxers. Proceedings of International Conference of Biomechanics in Sport, XXV ISBS Symposium 2007, Ouro Preto-Brazil, 591-594.

Ebben,W.P., Wurm, B., VanderZanden, T.L., Spadavecchia, M.L.,Durocher, J.J., Bickham, C.T., et al. (2011). Kineticanalysis of severalvariations of push-ups. *J StrengthCondRes*, 25: 2891–2894,

Filimonov, V.I.,Koptsev, K. N.,Husyanov, Z. M.,Nazarov, S. S.(1985). Means of increasingstrength of the punch. *National Strength&Conditioning Association Journal,* 7(6), p. 65-66.

Ghosh,A.(2010). HeartRate, OxygenConsumption and BloodLactateResponsesDuringSpecificTraining in AmateurBoxing. *International Journal of AppliedSportsSciences,* 22 (1), 1-12.

Hanon, C., Savarino, J., Thomas, C. (2015). Bloodlactate and acid-base balance of world-classamateurboxers afterthree 3-minute rounds in internationalcompetition. *J StrengthCondRes,* 29, p.942–946.

Hatfield, F. (2003).GeneralPoints Of ConditioningForBoxers. on-line: bodybuilding.com/fun/luis14.htm,

Chadlia, S., Ababou, N., Ababou, A.(2014).A newinstrumentforpunchanalysis inboxing. *Procedia Engineering*, 72: 411 – 416

Krška,P.,Hubinák,A., Šiška,Ľ., Czáková, M. (2019).Comparison of heart rate duringthespecificload and trainingmatch in boxing. *International Journal of PhysicalEducation, Sports and Health*, 6(5), 142-145

Lockwood, C., Tant, C. (1997).Mechanical and electromygraphicalanalysis of a boxer'sjab. In:*15 International Symposium on Biomechanics in Sports.*

Loturco, I., Nakamura, F.Y., Artioli, G.G. Kobal, R., Kitamura, K., Abad, C.C.,et al. (2015). Strenght and power qualities are highlyassociatedwithpunchingimpact in elite amateurboxers. *J StrengthCondRes,* 30(1), 109-116.

Nikolaidis, P.T.,Clemente, F.M., KrzysztofBuśko, K., Knechtle, B.(2017).Physiologicalresponses to simulated boxing: theeffect of sittingversusstanding1 body positionduringbreaks – a pilot study. *Asian J Sports Med,* In Press: e55434.

Nunan, D. (2006). Developmentof aSportsSpecificAerobicCapacity Test for Karate - A Pilot Study. *J Sports Sci Med,* 5(CSSI), 47–53.

Ouergui,I., Hssin, N., Haddad, M., Franchini, E., Behm, D.G., Wong, del P.,et al. (2014).Time - motionanalysis of elitemalekickboxingcompetition. *J StrengthCondRes,* 28(12), 3537-3543.

Ouergui,I.,Houcine,N., Marzouki, H., Davis, P., Zaouali, M., Franchini, E., et al. (2015). Development of a NoncontactKickboxingCircuitTrainingProtocolThatSimulates Elite Male KickboxingCompetition. *J StrengthCondRes,* 29 (12), 3405-3411.

Podstawski,R., Żurek, P., Clark, C.T., Laukkanen, J., Markowski,P.,Gronek, P. (2019). A multi-factorial assessment ofthe 3-Minute Burpee Test.*J PhysEdSport*, 19 (2), 1083 – 1091.

Šiška,Ľ., Broďáni, J. (2016). Analysis of a Boxingmatch - A pilot study. *J PhysEdSport*, 16(4), 1111 – 1114.

Šiška,Ľ., Broďáni,J. (2017).Use ofBurpees inCombatSportsConditioningTraining – A Pilot Study. *International Journal of Sports and PhysicalEducation,* 3(4), 1-6.

Šiška L, Kováčová, N., Pecho, J., Šutka, V.(2018). Possibilities of strength-endurancepreparation inboxing. [in Slovak]. *In Atletika 2018*. Proceedings of a scientificconference. Nitra: PF UKF. s. 143 – 152.

Tasiopoulos I, Tripolitsioti, A., Dimitrios, S.,Nikolaidis, P.T.(2015).Thegreaterthenumber of winsthe greaterthepeaktorquelevels of shoulderinternalrotatorspower of dominanthand in boxing. *JournalBiology of Exercise*, 11(1), 65-67.

Thomson,E., Lamb,K. (2017).Quantification of thephysical and physiologicalload of a boxing-specific simulationprotocol. *International Journal of PerformanceAnalysis in Sport*, 17(1-2).

Zalleg,D.,Dhahbi, A.B., Dhahbi, W., Sellami, M., Padulo, J., Souaifi, M., Bešlija, T.,et al. (2018).Explosive push-ups: From popular simple exercises to valid tests for upper-body power. *J Strength Cond Res*,doi: 10.1519/JSC.0000000000002774. Online ahead of print.

Zemková, E., Hamar, D. (2001).Assessmentof disjunctivereaction-speedabilities.[in Slovak]. Bratislava : FTVŠ UK. p. 6 − 26. ISBN 80-89197-55-8.