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Development of strength-endurance with regard to Pmax in conditioning preparation in boxers

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Abstract
The aim of this work was to compare two power programs with different intensity and different rest interval in the summary length of the competitive boxing match with respect to Pmax production and following decline in efficiency also with respect to physiological parameters of heart rate and lactate level. The power programs consisted of repeating the one power clean repetition – to run on the regular intervals after the beep. The performance was measured in watts by TENDO power analyzer. Under the weight of 65 kg barbell and after the 39 repetitions was the average power 763, 36±48, 7W and overall performance decline was 11, 87%. Under the weight of 55 kg barbell and after the 57 repetitions was the average power 796, 67±21W and fatigue index 0, 66%. The highest heart rate was in the both cases 162bpm, which is 91% from maximum. The lactate level was in the first case 11, 6mmol and in the second case 12, 6mmol. In development of endurance in power in the specific time mode we recommend the weight of the barbell around 85% from the maximum power weight where we can achieve similar values as with the maximum power weight while the fatigue index retains lower percentage level. We recommend join this power program to the training process of fighting sports.

Keywords: boxing, power production, power clean, tendo, heart rate, lactate

1. Introduction
Power training is one of the most decisive element in almost every sport whether as a prevention from injuries but especially from its ability to transform into the speed in motion. There are clear recommendations for weightlifting and multi-joint exercises in area of conditional preparation. Research has shown that the most effective strength development with involvement of fast glycolysis fibers is in progress in the spectrum higher than the 90% of maximum power. Achieved power is the sum of weight of the barbell and average speed in concentric exercise phase [1, 2, 3]. One of the basic exercise which is very often used in process of diagnostic is the power clean - performed from the ground or in the series mostly from the waist area [4, 5, 6]. The duration of one repetition, which is performed in the full range from the ground to the ground is about 5 seconds and it is good to use it in the short interval training.
In terms of endurance in boxing or kickboxing, the combatant must be able to repeatedly perform explosive moves throughout the duration of the match with the least possible decrease in performance, while the internal response of the body in the case of blood lactate level stays in the range of 11-16 mmol and the heart rate stays in the sub-maximum to maximum range [7, 8, 9]. Alternation of the high-intensity phases with passages with lower intensity is in a ratio of 1:1 to 1:2. Duration of high-intensity phase is about 1-2 seconds. The longest active phase has 5 seconds duration and it is characterized with diverse mixture of punches [10, 11]. When we realize the ratio between the high-intensity and low-intensity passages in 5 seconds long workout which can be the power clean, we can combine it with 5 or 10 seconds long pause. By this way we can achieve interrupted short-interval load on principle cluster sets [12, 13, 14]. Many authors have focused on the time characteristics in their researches and they created a training load in duration of competitive boxing or kickboxing match. The loads differ by their content and they used general and special means [15, 16]. This was inspiration also in our research. We have tried to suggest short-interval load appropriate for the fighting sports, to draw up its assessment methodology and to verify the impact of two types of loads with different intensity and different rest interval [17, 18].

2. Materials and Methods
2.1 Subject
The research was attended by a single sportsman aged 37, height 172 cm, weight 70kg, HR max. 178bpm. The total sports age of the sportsman is 30 years and he is a multiple Slovak champion in athletics and kickboxing.

2.2 Test Description
The kinetic programs were preceded by diagnosing the performance maximum during the lifting of weights from the ground in the full range and subsequent controlled placement of the weights on the ground using the diagnostic series. The methodology consisted of measuring the performance in series carried out with maximum effort in the concentric phase of movement with the individual dumbbell weights. The test began with a weight of 20 kg and continued with a 30, 40, 50, 55, 60, 65kg weight. When evaluating the measured data, we took into consideration the average and maximum values of the concentric phase of movement. This way, we have determined the performance maximum for the given

individual.

In terms of time, the power programs were identical to the timing of a boxing match, i.e. 3 x 3 minutes, with a 1 minute break between the rounds. The essence was to carry out one repetiton of the power clean "Movement at regular intervals on acoustic signal" which was repeated every 15s in the first case (C65), i.e. 13 signals per 3 minutes. This was followed by a 1-minute break and 13 more signals. This way, the subject carried out 39 repetitions for the duration of 3 rounds with a 65kg dumbbell. In the second case (C55), the acoustic signal repeated every 10 seconds, which represented 19 signals for the duration of 3 minutes. This was followed by a 1-minute break and 19 more signals. This way, the subject carried out 57 repetitions for the duration of 3 rounds with a 55kg dumbbell. The performance was recorded using the TENDO power analyzer. The average values in the concentric phase of the exercise were taken into account. The decline in performance was represented by the fatigue index (fig. 1).

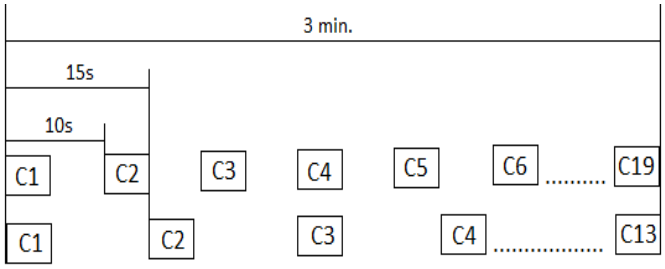

Fig 1: Schema of the loads

2.3 Statistical Techniques

The results reported in the test are described using the basic descriptive statistics "average time value of exercise" in each of the rounds, standard deviation, minimum value, maximum value and visual representation using box charts. The statistically significant differences in the mean values between the rounds were expressed by a T-test at the 5% and 1% level of significance. The substantive significance was assessed by the Cohen's "d" effect size coefficient. The subsequent time data for each repetition were displayed in a line chart and overlaid by a linear trend line. The performance drop (index of fatigue) is expressed as a percentage difference of the maximum and minimum values on the linear trend line with regard to the minimum value.

3. Results & Discussion

In the diagnostic series range, the performance maximum was identified with a 65kg dumbbell at 820W and the 90% band for the development of explosive strength was above 762, 3W, which matches the performance with a 60 and 65kg dumbbell. In the maximum performance range, the performance maximum was identified with a 60kg dumbbell at 1800W and the 90% band was above 1620W, which matches the performances with a 55, 60 and 65kg dumbbell (Fig. 2).

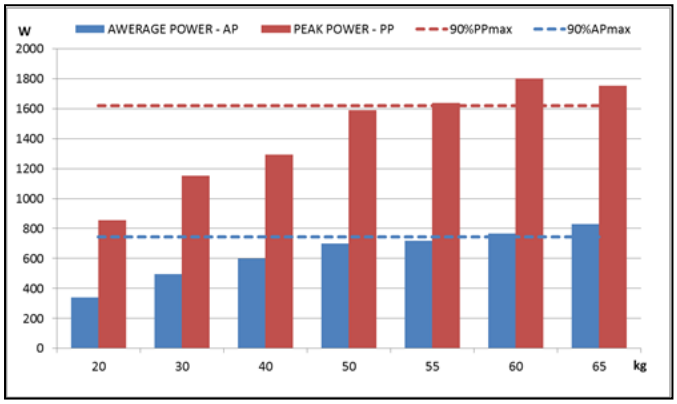

Fig 2: Results in diagnostic series

When comparing the monitored power programs, the performance was at a similar level only in the first round where an average performance of 806.38 ± 30.45W was achieved in C65 and 795.47 ± 24.22W in C55. In the second and third round, there was a significant drop to 741.62 ± 45.88W or 742.08 ± 38.34W in C65. In C55, the average performance values were roughly at the same level as in the second and third round, i.e. 797.16 ± 18.95W or 797.37 ± 20.56W. The best and worst performance was achieved in C65: 860 and/or 637W. Statistically significant differences in mean values in C65 were found between the first and the second round, and first and the third round, i.e. $p<0.05$. In C55, no statistically significant differences were found, i.e. $p>0.05$ between (Fig. 3).

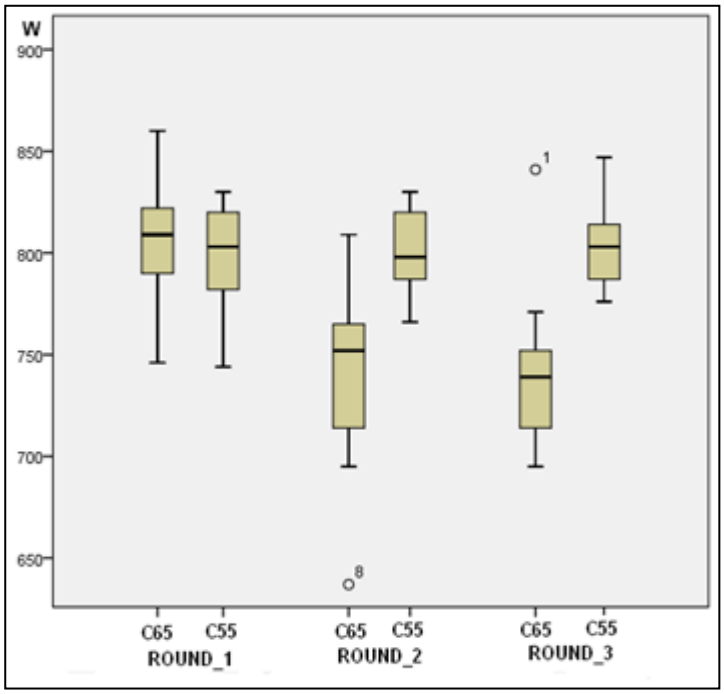

Fig 3: Box graph of measured values

The performance decline (fatigue index) was clearly identified in C65 in all three rounds, i.e. 11.87%. Best performance was achieved in the first round (860W) and the 90% band was over 774W. There were altogether 15 performances in this interval, which represented 38.5% of the total number of repetitions. In C55, the fatigue index was 0.66%, the best performance was 847W, and when considering the band above 90% of maximum performance 860W, altogether 51 performances of the total number of repetitions were traced in this interval, which represented 89.5% (Fig. 4).

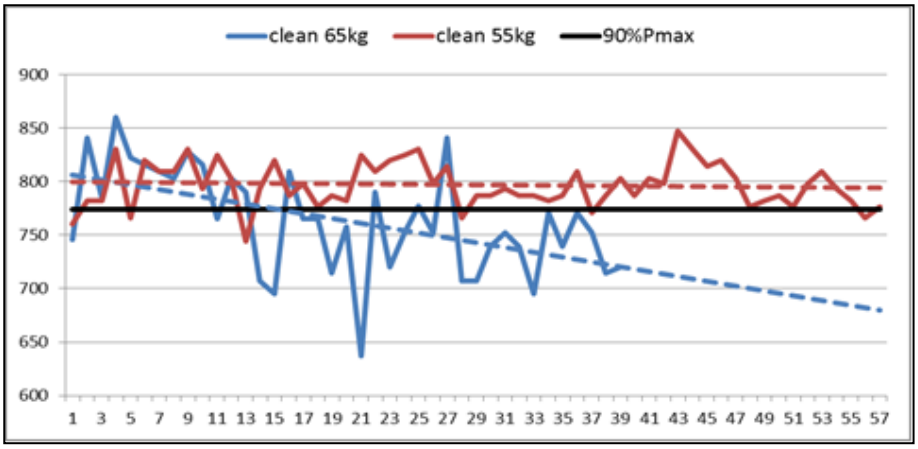

Fig 4: Time values of the individual repetitions, their linear trending and 90% of Pmax

Heart rate had a similar development in both programs with slightly higher values in C55 in the first and second round, i.e. 148 and 157bpm compared to 144 and 153bpm in C65. The maximum value in both programs was reached in the third round just before the end at 162bpm, and this value represents 91% of the performance maximum measured in the given person. A substantial drop in heart rate during the 1-minute pause was recorded in C65 by 32bpm after the first round and 26bpm after the second round versus 26 bpm after the first round and 13bpm after the second round in C55 (Fig.5).

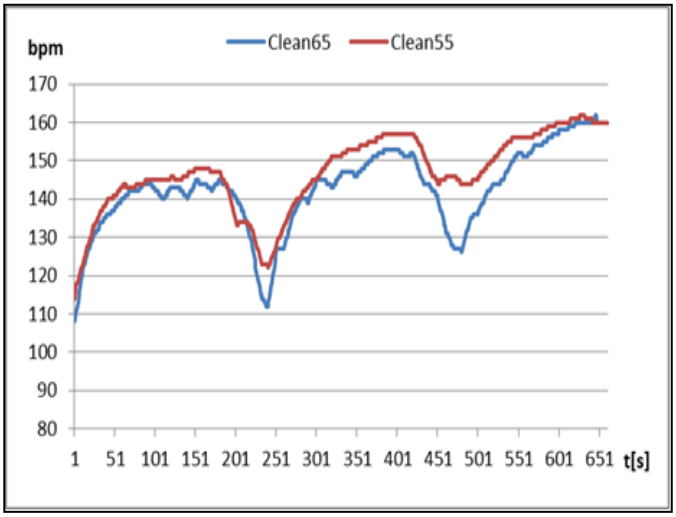

Fig 5: Course of Heart Rate during Exercise

The lactate level in C65 increased from the first to the second minute by about 0.5mmol from 11.1 to 11.6mmol and subsequently dropped in the third and fourth minute. The overall decrease from the first to the fourth minute was 1.4mmol. In C55 the maximum value 12.6mmol was measured already in the first minute with a subsequent decrease by 2mmol (Tab. 1) up to the fourth minute.

Table 1: Lactate level in measured loads

La	1 min.	2 min.	3 min.	4 min.
C65	11, 1	11, 6	10.8	10.2
C55	12, 6	11, 7	11, 2	10.6

The work demonstrated the possibilities of strength development in specific time conditions and with a view to performance. So far we have not noticed a study which would analyze performance and its decline in a similar way, therefore we have no benchmarks to compare our results with. Šiška [17, 18] observed fatique index but it was different exercises like burpee and short sprints. Decrease in performance was at level approximately 20%. In terms of maximum performance we recorded similar values around 1800W as Pennington [4], however, in their research, the weight movement was only tested in a single recurrence. Flores [5] recorded maximum performance in weight movement from 1700 to 3700W, which in some cases are considerably higher values than in our research but it is understandable since the research sample consisted of weight-lifters only. The highest values were recorded by Kilduff [6] 4466 ± 477 W, which could have been caused by a different measurement methodology. From the perspective of physiological parameters we achieved similar results in heart rate (around 90% of the maximum measured in the given individual) and lactate value in the blood from 11 to 16 mmol, as mentioned by authors in other studies [7, 8, 9, 16]. When summarizing our study, it is interesting to note that in the diagnostic series a performance of 717W was achieved with the 55kg weight while in the actual 3x3 min load it was 847W, which is a significant increase. The highest performance was achieved in C65 (860W). For this reason, it appears that a dumbbell weight of 55kg is more favorable. The maximum performance was at a similar level, whereby the average values were higher and the physiological parameters were also slightly higher. In comparison with a competitive match, of course, the load type is different but the time characteristics

are similar. In the match the repeated production of the highest performance with as little fatigue as possible is crucial, and it is also a prerequisite in our programs. When included into the training process on a regular basis, it is possible to intensify load in more ways, e.g. by reducing time or by increasing the weight of the dumbbells.

4. Conclusions

In conclusion we can say that we succeeded in designing a short-interval load, which corresponds to combat sports, developing endurance in strength with a focus on performance. The recommended weight is around 85% of the performance maximum, which guarantees performance at maximum values. We recommend to include the designed power program into the training process in combat sports.

5. Acknowledgments

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