ORIGINAL ARTICLE

The limits of anaerobic glycolytic capacities of skilled wrestlers on the basis of anaerobic testing loads of different duration and character

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

Stanislaw Sawczyn[1ADE], Olena N Lusenko[2ABD], Viktor S Mishchenko[1ACD], Marcin Pasek[1BCD], Marcin Dornowski[1BCD]

[1] Department of Combat sports, University of Physical Education and sport, Gdansk, Poland
[2] National University of Physical Education, Kiev, Ukraine

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Abstract

Background & study Aim: It is known that a fatigue response underlies the efficient of elite wrestlers' specific work capacities. Differences in fatigue and characteristics of special work capacity may relate to differ in capacities of anaerobic lactate systems. The objective of the study was the maximal individual level of anaerobic glycolytic capacities of skilled wrestlers based on the results of three variants of a specific laboratory test.

Material & Methods: Thirty-four free-style wrestlers of national and international level of middleweight category, aged 19-28 years with body mass from 76.9 (64-89) kg having engaged in sports training for 5-13 years participated in studies. All subjects performed three variants of maximal ergometric anaerobic lactate tests: 30 s, 60 s, 120 s and test 4, 30 s each (recovery interval 30 s) on cycle ergometer. They have been performed within days after the recovery micro cycle in the control training sessions. Anaerobic tests were performed the day after the previous test. Work output was measured. Lactic acid concentrations in capillary blood were determined on the 3rd minute after tests. We measured VO_2max also for estimation of the part of aerobic energy in different anaerobic lactate tests. The graded (2 min) load power increment on cycle ergometer to failure (12-16 min) was applied. Oxycon Pro (Jaeger) was utilized in breath by breath mode. Lactic acid concentrations in capillary blood were determined on the 3rd minute after the tests (LP-420, Dr. Lange). Percentile zones for determining the levels of test indices were distinguished, which could be the initial standard for differentiation of high and very high capacities of some athletes or groups of wrestlers of middleweight category.

Results: During longer anaerobic tests (60 s and test 4, 30 s each) higher blood lactate concentrations were observed as compared to 30-s Wingate test, even despite less total work (on a per 30 s basis). The lowest aerobic component of work energy supply in long-term anaerobic tests was noted during 60-s load. The lowest individual variations occurred during 120-s continuous load. The aerobic energy supply at the end of test 4, 30-s each was realized to a greater extent as compared to other anaerobic tests.

Conclusion: Determination of individual prerequisites to realization of wrestlers' anaerobic glycolytic capacities necessitates 2-3 testing with anaerobic type loads of different duration. Practical significance of the study may consist in the advance of additional criteria for regimes of training load with reason for individual predisposition of wrestlers.

Key words: free-style wrestling • individualities • specific work capacity • training and testing • anaerobic

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Author's address: Marcin Dornowski, University of Physical Education and sports, Kazimierza Gorskiego street 1, 80-336 Gdansk, Poland; e-mail mdornowski@awf.gda.pl

INTRODUCTION

Energy mode – characteristics of the relationship in metabolic capabilities of anaerobic (phosphate, lactate) and aerobic work energy supply systems for sports specific exercises**.**

Anaerobic glycolysis – transformation of glucose to lactate when limited amounts of oxygen are available. It has larger fuel fast supplies and it doesn't fatigue as quickly as the ATP-PC system.

Special working capacity – characteristics of particular aspects of specialized physical fitness and some specific elements of technical actions.

Anaerobic characteristics – variables determining a wrestler's anaerobic capacity: peak power, mean power and blood lactate concentration.

A sport wrestling is characterized by multi-factoriality and high versatility of demands to various aspects of body capacities [1-4]. This envisages wider, than in other sports events, range of skilled wrestlers' individual capacities, and, above all, those of functions and metabolism that underlie special endurance. studies of wrestlers' functional fitness are mainly focused on the key functions and factors that determine special work capacity. Taking into consideration the fact that a sport wrestling represents the sports event with high intensity of energy expenditure during competitive warsle, an increased focus during choosing the methodical direction of studies was put on the body energy capacities [1, 5-9].

Freestyle wrestling includes upper and lower body wrestling and is characterized by short duration, high-intensity intermittent effort that lasts a total of 6 min for senior and junior wrestlers (2 × 3-min bouts) [3,10, 11]. Anaerobic power is crucial because of the scoring system for freestyle wrestling [7, 12-15]. Modern wrestling has the tendency towards further increase of wrestling match intensity and accordingly the role of special endurance determining the level of sports master ship [9, 15, 16]. Great number of actions (holds) connected with hard overcoming opponent's resistance, his lifting, ability to disclose him and to force own hold upon him within short time interval necessitate very high level of speed-strength capacities. Abilities of anaerobic alactate and glycolytic systems represent an energy prerequisite for these capacities. Anaerobic glycolysis is only an effective means of energy production during short, intense exercise, providing energy for a period ranging from 10 seconds to 2 minutes [4, 17]. Many studies indicated particular significance of glycolytic anaerobic capacities and anaerobic endurance for the achievement of the high level of special endurance in sports wrestling [7, 12, 18-20].

This is shown by the results of the analysis of the character and duration of the periods of maximal tensions and "spurts" in the course of wrestling match. This is also indicated by the character and the degree of the body internal milieu after competitive wrestling match, when the blood pH in skilled wrestlers decreases to the values of 7.134 to 7.173. In juniors, pH decrease reached the values of 7.178 to 7.189 under these conditions [7, 21]. The degree of pH and blood lactate content decrease does not depend on the weight categories, but is rather related to individual result of wrestling match – winner or loser [7]. In this regard, it is suggested to use the degree of these indices shift as a criterion of fatigue after competitive wrestling match and potential of wrestler special work capacity. It is known that quantitative estimation of lactate power and capacity is connected with some difficulties and uncertainties [4, 17, 22]. some studies emphasize that the specificity of the qualified wrestlers energetic potential depends not only on the peak levels of anaerobic processes, but also the ability to realize this potential in a mixed aerobic-anaerobic mode [1, 6, 7, 18]. The present study is a continuation of this approach.

Many authors accentuate the importance of the ability to resist increasing metabolic acidosis (lactate-acidosis) for maintenance of high movement coordination under conditions of increased fatigue rather than the high anaerobic glycolytic power [9, 16, 19, 20]. Blood lactate concentration reaches 10-13 mmol.L^{-1} and 15-19 mmol.L^{-1} after training and competitive wrestling match, respectively [7, 19, 21, 23-25]. The above increases the importance of specific speed-strength endurance, which depends upon level of anaerobic glycolytic capacity and resistance to lactic acid in muscles and blood. The duration of "spurts" and intervals between them are different in the athletes so one may assume that there are differences in involving of anaerobic glycolytic process of wrestlers with different manner of wrestling match conducting [19]. Inter-individual variability of these characteristics is related to kinetics of involvement of different energy systems in the process of wrestling match. It is, therefore, safe to assume that aptitude for individual variants of duration of "spurts" and its regularity related not only to peaks of anaerobic glycolytic power but to anaerobic glycolytic capacity. These aspects of wrestler's capacities have been studied insufficiently.

We have proceeded from the fact that wrestlers of homogeneous according to sports qualification group have differences in anaerobic glycolytic possibilities, difference relations anaerobic lactate power and capacities. They may be demonstrated during comparison of the results of maximal anaerobic glycolytic tests of different duration – short, average and long.

The objective of the study was the maximal individual level of anaerobic glycolytic capacities of skilled wrestlers based on the results of three variants of a specific laboratory test.

MATERIAL AND METHODS

Participants

Thirty four free-style wrestlers of national and international level of middleweight category, aged 19-28 with body mass from 76.9 kg (64-89 kg) having engaged in sports training for 5-13 years participated in studies.

Studies design

Main studies have been carried out during 24-day training camp at special preparatory period of annual preparation cycle. The content of studies was approved by local Commission for scientific study ethics. All subjects performed three variants of maximal ergometric anaerobic lactate tests: 30 s, 60 s and 120 s. They have been performed within two days after the recovery microcycle in the form of control training session as follows. Each next anaerobic test was performed the day after the previous test. studies have been conducted on experimental base of the scientific and Research Institute of the National University of Physical Education of Ukraine.

Justification of tests and measurements.

We have proceeded from the fact that specificity of wrestler anaerobic capacities requires testing of its various manifestations. Unified tests, widely tried during work with highly skilled athletes and recommended for usage on a uniform standard basis, have underlain the complex of ergometric methods for estimation of anaerobic glycolytic capacities [4,17,26]. In this respect three variants of anaerobic tests were applied: short (30 s), intermediate (60 s) and long (120 s) according to procedures proposed by Bouchard et al. [17]. In addition was applied test 4, 30 s each (recovery interval 30 s) [7, 18]. Tests were performed twice (every other day) in laboratory conditions using Monarch cycle ergometer (Monark 824E mechanical ergometer). The one minute special wrestling tests contained throws of man-simulator at maximum pace were used as well [21]. Man-simulator weight constituted 40-46% of athlete body mass. Time interval between these anaerobic tests constituted 30-35 min. Maximum value was chosen according to the results of two measurements. Working output and 5 s peak power (for 30 s test) were determined. Lactic acid concentrations in capillary blood were determined on the 3rd minute after tests (LP-420, Dr. Lange). Test of graded (2 min) load power increment on cycle ergometer to failure (12-16 min) was applied for aerobic power (VO_2max) estimation. Measurement of VO_2max was applied for estimation of the part of aerobic energy in the anaerobic lactate tests. Oxycon Pro (Jaeger) apparatus was utilized in breath by breath mode.

Statistical analyses

Differences between groups were performed using a statistical software package (STATISTICA 8). Data were checked concerning normal distribution by Cochran, Hartley, Bartlett and M. Box test. All data were found to be normally distributed; therefore analysis was carried out using parametric statistical tests. Values were presented by means, standard deviations, and significance was set at the $p<0.05$ level. During analysis of findings correlation links of some indices were determined (according to spearman). Outlining of percentile ranks was used in order to determine the levels of high and very high indices in tests. These data contribute to elaboration of standards and differentiation of the capacities of this type of individual athletes or groups of wrestlers of the middleweight category. Zones for values of 70-100% and 95-100% were selected.

RESULTS

Measurement of anaerobic capacities of skilled wrestlers on the basis of 30-s Wingate test, which, according to the duration of anaerobic glycolytic tests, was referred to intermediate ones, has demonstrated wide range of inter individual variations (Table 1).

Determination of characteristics of performed work during longer anaerobic tests (60 s and 120 s) indicates a natural decrease of work volume along with the increase of test duration (on a 30 s basis) (Table 2). For instance, during 60-s maximal load total work decreased only by 10.3% as compared to 30-s load of Wingate test. Greater decrease was observed during 120-s continuous load (by 35.6%). The least decrease was noted in average peak power of the series of maximal

Table 1. Characteristics of the level and the range of variations of total work and peak power according to the results of 30-s test of maximal intensity (intermediate anaerobic test).

Variable and indicator	Mean (SD)	Range (min÷max)
Maximal total work during 30-s load (J·kg^{-1})	291 (18.1)	265÷318
Peak power during 30-s load (W·kg^{-1})	13.0 (1.0)	9.9÷15.7
Fatigue index	43.5 (4.1)	29÷56

Table 2. Characteristics of the level and the range of variations of total work and peak power during long-term anaerobic glycolytic tests.

Variable and indicator	Mean (SD)	Range (min÷max)
Total work of 60-s maximal intensity load (J·kg^{-1})	511 (38)	420÷580
Number of man-simulator throws within 1-min maximal wrestling test	25.1 (1.9)	19÷28.5
Total work of 120-s maximal intensity load (J·kg^{-1})	802 (64)	601÷902
Average peak power of the series of maximal intensity loads (test 4, 30 s each) with 30 s interval (W·kg^{-1})	11.3 (0.8)	8.4÷12.3

Table 3. Maximal blood lactate concentration (mmol·L–1) and the range of variations after (in the 3rd min) anaerobic glycolytic variations of test.

Variable	Code	Mean (SD)	Range (min÷max)
after 30-s test	1	14.0 (0.8)	11.1÷15.9
after 60-s test	2	15.2 (0.5)	11.9÷17.9
after 60-s wrestling test	3	13. 0(0.9)	8.8÷17.8
after120-s test	4	12.9 (0.7)	9.9÷15,6
after test 4, 30 s each	5	16.8 (0.7)	13.2÷19.1

Differences in mean values 1,2-3, 1,2-4, 1,2-5 and 3,4-5 are significant at $p<0.05$

intensity loads (4, 30 s each). It constituted 9.1% only. The range of variations of individual indices (min-max) was significant in the majority of indices despite homogeneity of the group of wrestlers in sports qualification. significantly less variability of the maximal number of man-simulator throws per 1 minute was observed, which was related to a relative coordination complexity of man-simulator throws and restriction of throw frequency. Lower variation range of peak power individual indices in the series of maximal intensity loads (4, 30 s each) as compared to 30-s Wingate test.

During longer anaerobic tests (60 s and test 4, 30 s each) higher blood lactate concentrations were observed as compared to 30-s Wingate test, even despite less total work (on a per 30 s basis) (Table 3). The highest blood lactate concentration like its maximal level in some wrestlers was observed after test 4, 30 s each, whereas the lowest – after 120-s test. At the same time, the characteristics of some wrestlers reached significant values after 120-s test.

The lowest aerobic component of work energy supply in long-term anaerobic tests was noted during 60-s load. The lowest individual variations occurred during 120-s continuous load. The aerobic energy supply at the end of test 4, 30-s each was realized to a greater extent as compared to other anaerobic tests. The highest blood lactate concentration was also observed after the same load (Table 4).

The percentile zones of high and the highest characteristics were determined according to two key indices – maximal total work and blood lactate concentration in tests of different duration (Table 5).

Table 4. Level of oxygen uptake (in % of VO_2max) during the last 30 s of anaerobic glycolytic tests of 60-s, 120-s and test 4, 30-s each.

Variable	Code	Mean (SD)	Range (min÷max)
60-s test	1	69.2 (4.9)	58.7-74.9
120-s test	2	82.7(3.7)	79.0-92.2
test4, 30-s each	3	86.6(4.1)	79.8-95.1

Differences in mean values1-2, 3 and 2-3 are significant at $p<0.05$

Table 5. Percentile zones for estimation of high and very high individual indices of anaerobic lactate capacities of skilled wrestlers (in parentheses the number of wrestlers).

Variable and indicator	Percentile zones	
	70-100%	95-100%
Maximal total work during 30-s load on cycle ergometer ($J \cdot kg^{-1}$)	292-318 (8)	303-318 (1)
Peak power during 30-s load ($W \cdot kg^{-1}$)	13.3-15.4 (7)	13.0-15.4 (2)
Maximal blood lactate concentration after 30-s load ($mmol \cdot L^{-1}$)	14.1-15.9 (8)	14.8-15.9 (1)
Maximal total work during 60-sload on cycle ergometer ($J \cdot kg^{-1}$)	541-590 (8)	565-590 (1)
Maximal blood lactate concentration after 60-s load ($mmol \cdot L^{-1}$)	15.6-17.9 (7)	16.4-17.9 (2)
Total work of 120-smaximal intensity load ($J \cdot kg^{-1}$)	756-902 (7)	867 -902 (2)
Maximal blood lactate concentration after 120-s load ($mmol \cdot L^{-1}$)	13.5-15.9 (8)	14.6-15.9 (1)
Maximal blood lactate concentration after load test 4, 30 s each ($mmol \cdot L^{-1}$)	16.0-19.4 (7)	18.1- 19.1 (2)

DISCUSSION

Studies have demonstrated that utilization of intermediate in duration and longer anaerobic tests allows obtaining the important data about anaerobic glycolytic capacities of skilled wrestlers that significantly supplement the results of traditionally applied 30-s Wingate test. This increases the possibility of assessing of both anaerobic power and capacity of anaerobic glycolytic processes. Characteristics of anaerobic capacity level are presented according to indices of maximal work, peak power and maximal blood lactate concentration. Footwork was used as it permits to reach close to maximal and higher, as compared to handwork, blood lactate concentrations. In addition, the level of aerobic energy supply during realization of anaerobic glycolytic capacities was estimated. As far as the large group of highly skilled wrestlers has been studied, these data may be used for elaboration of standard levels of these capacities. Besides, application of the complex of anaerobic loads of different duration and type creates possibilities for assessment of individual predisposition to realization of anaerobic glycolytic capacities.

Examined wrestlers had higher specific values of anaerobic lactate power (30-s test), similar to those reported in skilled speed skaters and runners [4, 17] and in Greco-Roman wrestlers [11, 27]. It has also been shown previously that peculiarities of realization anaerobic potential were in connection with special working capacities [9, 16, 18, 20, 28]. At the same time, rather wide range of variability of the anaerobic lactate power (30-s test) characteristics is noteworthy, although it is lower than that demonstrated for anaerobic alactate power [12, 13, 16, 19]. While interpreting the results of 30-s test, one should take into account the fact that the total result of the given anaerobic test includes also the capacity of work alactate energy supply, although the major part of total energy release is provided at the expense of glycolysis. The wide range of individual differences in fatigue index is probably related to uncertainty of ratios of these two energy systems.

During application of longer anaerobic tests, the contribution of alactate energy supply to total energy release drastically decreases, losing its influence on total estimation. At the same time uncertainty is introduced that is connected with reflection in this test of both the power of lactate

energy system and its capacity. Due to the above, three types of cycle ergometry tests of such kind were used.

Characteristics of longer (60 s and 120 s) tests for assessment of anaerobic lactate capacities confirm the data about the high level of this aspect of energy capacities of skilled wrestlers and greater significance of this fitness component for sports wrestling. Taking into consideration the fact that skilled wrestlers of homogeneous group have been examined, the low index of blood lactate concentration could be interpreted as a relatively low lactate (glycolytic) efficiency, whereas the upper level – as the high one. Rather wide range of individual variations was peculiar for these indices, approximately expressed in the same way as during intermediate in duration (30 s) anaerobic test. High variability of individual indices was noted in maximal blood lactate concentration, and especially after 1-minute wrestling test. This characteristic showed the greatest degree of variation after wrestling test – from 8.8 to 17.8 mmol·L^{-1}.

These data are similar to those reported in other studies in which the above wrestling test was used [18, 21]. It may indirectly indicate the higher individual peculiarities of the realization efficiency of lactate energy supply system capacities during throwing test execution, envisaging different increase of blood lactate concentration per unit of power enhancement (number of throws in the given test). Quantitative analysis of such kind, however, is complicated in the given test. This indicates a relative restriction of informatively of such wrestling test for assessment of anaerobic lactate capacities. Less variability was observed in maximal blood lactate concentration after 60-s load on cycle ergometer and test 4, 30-s each. In this case, the indicated range decreased only at the expense of high minimal values as compared to 1-min wrestling test.

Comparison of data presented in Table 3 with those observed in outstanding wrestlers – World, European and Olympic champions, confirms this point of view [7, 9, 11, 21, 23]. According to available data, standard model value of blood lactate concentration constitutes 14-19 mmol·L^{-1} after competitive wrestling match [21]. During determining model parameters of training process at the stage of direct preparation of highly skilled free-style wrestlers (members of the national teams of the former USSR and Russia), an average value of maximal blood lactate concentration during training and competitive exercises equal to 17.7 mmol-L^{-1} is presented [7, 21]. Model values of this index are set within the range of 13-23 mmol·L^{-1}. Later studies confirm presented data and indicate high correlation between maximal values of blood lactate concentration and sports efficiency and wrestlers' rank [15, 16, 18, 19, 25]. It is one of the evidences of the importance of using testing protocol that permits to achieve individual limits of anaerobic lactate capacities.

Therefore, analysis of individual variations of indices in intermediary and long-term tests that mainly reflect anaerobic capacity, has demonstrated availability of sufficiently wide range of individual peculiarities in highly skilled wrestlers. This gives grounds for usage of several gradations of index levels for practical assessment of the level of development of this aspect of energy capacities in each specific athlete. Certain grounds for this are given by outlining percentile zones of high and very high indices, presented in Table 5. since in our studies were used data of highly skilled wrestlers including those of international level, then they may be used as standard ones.

Meanwhile, even among the world level wrestlers a sufficiently wide range of individual variation of indices, reflecting anaerobic lactate capacities of the body, is observed. It depends on the type of anaerobic test to a great extent. Intermediate in duration 30-s Wingate test fails to sufficiently reflect anaerobic glycolytic capacities of wrestlers. The most complete realization of these capacities is achieved during long-term anaerobic tests and, above all, during 60-s test and test 4, 30-s in each with 30-s rest intervals. In this case, the low level of maximal lactate concentration in skilled wrestlers is within the range of about 13 mmol·L^{-1}. For 30 % of the best wrestlers according to this index, this minimal level constitutes about 16.0 mmol·L^{-1}. It should be stressed that during long-term anaerobic tests maximal glycolytic capacities are realized in the face of high oxygen intake, which constitutes about 70-90 % of maximal oxygen consumption. That is why, such tests adequately reflect complex manifestation of wrestlers' special endurance and their ability to recover in the process of wrestling match. Due to the above, during such anaerobic tests one should determine not only the limits of

power and blood lactate concentration, but the level of oxygen intake as well.

Maximal amount of work significantly decreases during testing load prolongation. This decrease is especially evident during 120-s test. Application of this test is justified by the fact that it is focused on assessing maximal capacity of anaerobic glycolysis in provision of work with high aerobic component of energy supply constituting about 50 %. At the end of this test oxygen intake significantly increases reaching about 79-92 % of maximal oxygen consumption and significantly differing in athletes. During the processes of glycolysis hydrogen ions (H^+) are released into the muscle cell. Without oxygen the H^+ cannot be removed and as a result the muscle cell becomes increasingly acidic. It is important that the kinetics of blood lactate during wrestling match most affected by the level of maximal oxygen uptake [25]. In this regard application of the longest "flat" anaerobic glycolytic test should be aimed at assessment of not only anaerobic glycolytic capacity of wrestlers, but rather at the degree of its realization under conditions of anaerobic-aerobic work.

Modified anaerobic test with total duration of 120 s was used for the same purposes. It was performed in the form of four 30-s segments with 30-s rest interval. An important peculiarity of this test is it's the highest blood lactate concentration and simultaneous mobilization of glycolysis capacity for work provision. Value of peak power within working segments of test 4, 30-s each were close to those demonstrated by athletes during standard 30-s test. At the same time, the given test requires extremely high tension and is subjectively perceived as very hard. Therefore, it may be applied for testing of mature highly skilled wrestlers only. Conspicuous is the fact that in this case skilled wrestlers not only perform the highest volume of work in anaerobic glycolytic regime, but reach the higher level of work aerobic energy supply at the end of test. For instance, within the fourth 30-s part of load 80-95 % of individual levels of maximal oxygen consumption are achieved. Moreover, this percentage is higher, the lower the individual value of maximal oxygen consumption ($r = -0.71$). It should be noted that maximal values of blood lactate concentrations in all anaerobic tests had the range of variations, exceeding possible differences related to wrestlers' qualification and fitness at the time of testing. Furthermore, the higher the maximum concentration of lactate in the blood of individual wrestlers, the less they had characteristic VO_2max ($r = -0.69$). This may indicate either methodical peculiarities of testing or the wide range of differences in individual predisposition to preferential development of the capacities of one of the energy systems. In all cases it conflicts with suggested by some researchers' usage of the degree of acidotic shifts as a universal criterion of wrestlers' special endurance.

There are points of view that the differences in maximal lactate concentration may be related to individual stability to metabolic acidosis of muscular structures, in particular, rather than to the possibilities of glycolysis power enhancement during training [4, 17, 22]. There is a high probability that the most part of differences of highly skilled wrestlers is related to the above. We believe that these studies may be important in the interdisciplinary approach to the most important management of long-standing wrestlers at the highest sport level [29, 30] but also in the prevention of injury during combat training with a similar motor structure [31].

CONCLUSIONS

Thus, there are various reasons for the effective implementation of capacities anaerobic lactate system for special work capacity of wrestlers. It gives a basis to conclude that working out such estimates along with parallel using 2-3 tests and several indices may permit to obtain an objective estimation of the degree of anaerobic lactate capacity development during their testing for practical correction of training. In our opinion, this may provide grounds for standard base for determining different expressiveness of individual predisposition to work within the given power zone of skilled wrestlers. In this regard, there are reasons to believe that in order to determine individual predispositions to realization of anaerobic glycolytic capacities of wrestlers one should perform testing during different duration of anaerobic type loads.

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