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Original Article

Model for assessing the physical status, as well as prediction and programming of training and sports performance of a soccer player

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Abstract:
The goal of this study is to offer a complex model that enables the evaluation of physical status, as well as prediction and direct programming of training and sports performance of a soccer player. The behavior and characteristics of this model are presented through the results of a talented soccer player.In order to measure, evaluate and compare all variables to the performances of elite soccer players, as well as to assess and program training and soccer performance, the authors used a licensed hardware and software system. The initial results of the subject were below the performances of elite soccer players and lag behind their performances during soccer games. The rules of development and genetic potentials show that physical status and performance during games can be boosted above both thresholds after eight months of training. Excellent external output application, explication of causality between physical status and performance during soccer games, as well as hardware-software support, forecasting and designing soccer and training performance, support the fact that this model is an outstanding solution for everyday practice.
Key words: aerobic status; anaerobic status; status in speed; status in force

Introduction

In soccer, performance depends, among other things, on the application of complex models for the evaluation of soccer players' physical status. Nevertheless, it also depends on the application of hardware-software systems used for the analysis of sports performance, diagnostics, quantification of training goals, programming and control of trainings, training effects, changes and performance during games **(**Bangsbo et al., 2006; Milosevic**,** 2004, 2010b, 2012, 2013; Reilly, 2007**)**. There are two models for evaluating the physical status of a soccer player: western and eastern. According to Clarce(Clarce, 1945), the first modelwas developed by Sargent in 1902. This model aimed at evaluating the strength, speed and endurance of the human body. After Sargent, western scientists continued to develop and upgrade the model by using hypertrophied statistical apparatus. They tried to create instruments that would authentically reconstruct and imitate movements from sports practice (motor tasks) in order to establish control and explain the influence of physical status on sports movements and sports performance. This approach produced models with a huge number of physical skills defined through content and measurements of numerous motor tasks (different types of strength, balance, agility, coordination, flexibility, endurance, educability…).

In 1975, Yugoslavian researchers (Kurelic et al., 1975), using different motor tasks, the same as western scientists and with the same goal,built a hierarchical model for the evaluation of physical abilities from the standpoint of functional mechanisms, and without regard to test contents and measurements. The primary elements of their model are: the mechanisms regulating theintensity of motor neurons' excitation, a process responsible for the quantity of muscle force generated in a unit of time; the mechanisms regulating the duration of motor neurons' excitation, responsible for the quantity of work performed by certain muscle groups, i.e. for different types of static and repetitive strength; the mechanism regulating movement structure, responsible for movement coordination or the efficiency of solving complex motor tasks, as well as for the creation and reproduction of motor rhythm; and the mechanism for functional synergy and effector muscle tone regulation, responsible for the speed of movement, establishment and/or maintenance of balance, flexibility or amplitude of movement in certain joint systems, as well as the precision of certain movements. Secondary elements are: movement regulation mechanism and energy regulation mechanism. This model's tertiary element is the general mechanism for motor regulation.

In 1971, in Russia, independently of western researchers, Zatsiorsky (Zatsiorsky, 1971) develops a model for evaluating physical abilities of athletes based on physiology. The model was used to evaluate 5 basic skills that determine sports performance: strength, speed, endurance, agility, flexibility, and several variants of these skills, such asmyometric, plyometric, isometric, and repetitive strength, different types of speed and endurance, etc. In

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2001,Bompa (Bompa, 2001) used different approach and somewhat changes Zaciorsky'smodel. Bompa's model is used for evaluating essential physical abilities of athletes, their strength, speed, endurance, coordination and flexibility. He creates and evaluates the extracted abilities, such as explosive strength, speed endurance, agility, etc.using the interrelations of the essential skills for each motor activity (motor task). According to him, every sport is characterized by a specific interrelation between essential abilities that dictate the performance in a sports discipline. Other models mainly represent the variants of the three abovementioned models. Recently, western scientists upgrade models with new physical abilities such as force, long-term and short-term muscle endurance, cardiovascular endurance, aerobic and anaerobic status, plyometry. Nevertheless, most of these models are not always consistent with SI measurement system, a standard globally used for evaluating the physical status of athletes. They also have another deficiency: they are mainly based only on theories of physical/motor abilities.Due to a specific approach when making models, in the case of western authors, the same ability is expressed in different measurements, which are not in accordance with SI system. On the other hand, there are cases when several abilities are expressed using the same type of measurements. Sometimes, the same ability, for example, strength, is expressed using length or time or mass or number of repetitions; and vice versa, at other times,different abilities may be expressed using the same type of measurements. The second fault of the analyzed models is the fact that they evaluate only current state, without any regard to genetic potentials and rules of their development. The third fault of these models refers to the fact that output data cannot be programmed using training performance in accordance with measurements and requirements of games. The fourth fault is that standards for estimating diagnosed values were formed based on measured results, and not based on external criteria.

In order to eliminate these faults, this paper proposes a complex model based on the theory of stationary, current and transitional state or regime, development theory, capacity theory, structural and functional theories of physical abilities, adaptation and change theory, theory of effects, muscle force generation theories, motor control theory, integral muscle generation and motion theory, as well as on the results from the area of fundamental physiological and biophysical research (Milosevic, 2010a,b; Milosevic&Milosevic, 2013; Milosevic et al., 2000, 2004, 2012a,b; Osgnach et al., 2010; Reilly, 2007; Stølen et al., 2005).Simulation and evaluation of the model was performed on 390 subjects. The model proved to have a satisfactory level of objectivity, reliability, consistency, constancy, predictability, possibility of practical application. It also proved to be effective for explaining the influence of physical status on performance during a soccer game (Milosevic, 2010a, 2012; Milosevic et al., 2012a; Osgnach et al., 2010). The subject of the model's evaluation and forecast are aerobic and anaerobic status, as well as the status in speed and force on the level of state, genetic potentials, development functions and performance during games and trainings (Milosevic, 2004, 2010b, 2012, 2013).Standards for the valuation of physical status are based on test results, dimensions that describe the physical status of elite soccer players and their performance during world and European championships and champions league (Hoff, 2005; Milosevic, 2010 b; Milosevic et al., 2012a; Osgnach et al., 2010). All output data for the proposed model are expressed in SI system measures. The model has hardware-software support for data acquisition and analysis, selection, programming of game and training performance, recovery and performance during sports competitions (Milosevic, 2004, 2010a,b, 2012, 2013; Milosevic et al., 2012a,b). Behavior and properties of the proposed models are presented through the results of a talented soccer player.

Method

All measurements and calculations come from the performance of a talented soccer player: attacker, age 19, body height 175cm, body weight 63kg. The model used for this research comprises 4 complex elements. From the point of view of tactical reasoning, the subject can be classified as logical-systematical type of soccer player (Milosevic, 2010b). From the point of view of stress, he belongs to the group of soccer players with above-average stress recovery, very high stress tolerance and very small quantity of residual stress (Milosevic, 2010b). In extremely stressful conditions, he is among soccer players with very high tactical efficiency (Milosevic, 2010b).

The elements of this model are: aerobic status, anaerobic status, status in force and status in speed. The properties of each element are described using groups of status variables, genetic potential variables, development and forecasting functions. A number of the mentioned variables are measured directly, while the remaining variables are extracted from the results of measuring. Directly measured variables are: body weight, body height, time elapsed for 20m, 50m and 100m running from standing start, 20m from flying start, distance covered when running 1 minute and 12 minutes using standardized procedures (Milosevic, 2010b). The authors also performed direct measurements of force and force generation time in isometric and dynamic regimes using standardized procedures (Milosevic, 2010b). In dynamic regime, the authors measures the force of extensor muscles in legs, arms, back and shoulders, when lifting weights in half squat, dead lift, bench press and kettle bell clean with 70%, 80% and 85% of 1RM and 1RM; leg extensors in block drop jump from 110cm, drop jumpdepth jumpfrom 80 cm and vertical high jump. A certified hardware-software system was used for the measuring (Milosevic et al., 2004; Milosevic, 2010a,b, 2012).Peripheral equipment for taking the measurements included: tensiometeric probe with measurement range of 0-150000N and measurement accuracy of 0.0002N, free weights with equipment enabling us to measure time (s), vertical and horizontal changes in bar and weight position applied to the entire lifting range (vertical at each 5.8mm, horiyontal at each 1mm), tensiometric platform, electro-optical system for measuring movement parameters during testing. The designed system allows muscle length (angle), time of activity, velocity of shortening (concentric contraction) and muscle elongation (eccentric contraction), the time of transition from eccentric to concentric contraction (reversible contraction), weight mass and weight lifting speed to be controlled and varied during the measurement process. Tensiometric platform is used for measuring muscle force generation during different types of drop jump depth jumps, drop jumps or vertical jumps. Piezoelectric sensors embedded in the platform register at a high speed (500 Hz) the compression forces during the execution of drop jumps, drop rebound jumps, single or serial jumps and allow detailed dynamic analysis of all phases of the jump and a high validity of each executed movement. Apart from standard parameters, a tensiometric platform allows tracking of the dynamics and transitivity of the force development, the speed of executed jumps, the depth of a drop jump (or depth jump), the effects of stretching, the ability of rapid replacement of eccentric and concentric contractions as well as the transfer of elastic energy (Bobbert et al. 1996) and a number of other parameters.

Time, distances and speed of running, as well as age, body weight and height, were entered into the software and used to calculate variables that represent aerobic and anaerobic status of the subject, that is maximal and relative oxygen consumption, anaerobic threshold, oxygen consumption at anaerobic threshold, speed at which the subject spends the maximal amount of oxygen, speed at which the subject exceeds anaerobic threshold, energy efficiency of locomotion, maximal oxygen debt, short-term oxygen debt, speed of running at which the subject makes short-term oxygen debt, speed of running at which the subject makes maximal oxygen debt, the quantity spent glycogen and lactic acid at short-term and capacity quantity of oxygen debt, maximal distance covered by running in aerobic and anaerobic intermittent running regime, speed, time and distance of running using CP (Milosevic, 2010a,b; Osgnach et al., 2010; Milosevic et al., 2012a). Furthermore, the same data were used for calculating the status in speed, i.e. maximal running speed, running speed at different distances, the time necessary for initiating movement and the ability to accelerate. The data referring to time necessary for lifting weights was used to calculate vertical speed and acceleration for each monitored repetition as the first and the second derivative of distance per time.

The results of speed and acceleration were fitted before calculating force. The fitted data were used to calculate force for each repetition for the entire range of lifting. From the relation between force and time, derived from measuring in isometric and all dynamic conditions, the software was used to calculate status in force, i.e. the speed of force generation in concentric, eccentric and reversible contraction, change in force generation speed, the level of force necessary for initiating movement, maximal force of certain motor unit groups and dimensions that modulate the intensity of force: motor units activation speed, motor units synchronization, motor units optimization at intramuscular and intermuscular level, i.e. intramuscular and interpuscular coordination (Milosevic et al., 2004, 2012b; Milosevic & Milosevic, 2013). The software was also used for calculating the threshold of genetic potentials in all areas of physical status, the functions of development for this potential, as well as for forecasting and programming game and training performance (Milosevic, 2004, 2010a,b, 2012; Milosevic et al., 2012b; Tucker and Collins 2012). All measured and derived results recorded on the subject were compared to game performance requirements and to the results of elite European and global offensive players and other players. The subject's results were also used for defining his position in relation to the said requirements and results (Bangsbo et al., 2006; Hoff, 2005; Milosevic et al., 2012a; Osgnach et al., 2010; Reilly, 2007; Stølen et al., 2005).

Results

All measured and derived results were presented in a way that enables insight into properties, complexity, behavior and forecasting method for sports and training performance and represent a way to interpret output data from the proposed model.

Aerobic status

State in aerobic strength and capacity

The subject's VO_2 max is 3.7 l/min. VO_2 rel is at 60.24 ml/kg/min. The subject achieves this consumption at the speed of 4.66m/s and locomotion energy efficiency at 12.4%. His momentary aerobic strength is at 18.5 kcal/min. He exceeds aerobic threshold at 76% VO_2 rel which equals 48.6 ml/kg/min at the speed of 3.7 m/s. During active game time, per game, in aerobic regime, the subject's consumption is at 102.3 l of oxygen and 511.5 kcal which enables him to run 7326 m during a game.

Projected potentials

His forecasts are: VO_2 max at 4.9 l/min and VO_2 rel at 73.8 ml/kg/min with locomotion energy efficiency at 29.6%. His projected aerobic strength is 24.5 kcal/min. According to his genetic potential, he can exceed aerobic threshold at the speed of 4.9 m/s, instead of at 3.7 m/s with oxygen consumption at 66.4 ml/kg/min, instead of at 48.6 ml/kg/min, i.e. at 91% instead of at 76% VO_2 rel. According to the forecast, per single game, during active game time, he should achieve VO_2 max at the speed of 5.44 m/s and to spend 162.9 l of oxygen, 814.6kcal, and run the distance of 9,302.4 m.

The evaluation of aerobic status

The subject's test results are at 78.6% of projected relative oxygen consumption and at 68.6% of absolute oxygen consumption. He can use training to boost oxygen consumption by 21.4% and 32.4%, respectively. His locomotion energy efficiency is at 41.6% of projected value and he can increase it by 240%. The speed at which he achieves maximal oxygen consumption is at 83.3% of genetically projected value, which means that adequate training could help him improve it by 16.7% and achieve or exceed the current performance threshold of elite offensive players in this domain. The speed at which the monitored subject exceeds aerobic threshold can be improved by 20%, while threshold oxygen consumption can be improved by 27%, which is somewhat above the current threshold of performances of elite offensive players. Adequate training can be used to boost aerobic capacity by 27%, aerobic strength by 24.5%, length of distance covered by running during games by 26.9% - this means that he would exceed the current threshold of performances of elite offensive players and aerobic requirements of soccer games.

Anaerobic status

State

Strength of lactate system

For this subject, the maximal speed for generating capacity values of oxygen debt and lactate acid equals 6.5m/s. In one minute, at a distance of 366m and running speed at 6.1m/s, the subject is currently capable of generating an oxygen debt of 14 liters and 98 grams of lactic acid, to spend 98 grams of glycogen and 70kcal of energy.

Capacity of lactate system

The maximal oxygen debt the subject can generate in a single minute is 18 liters and 126 grams of lactic acid, while he spends 90kcal and 126gr of glycogen. He is currently capable of running the distance of 5,124m in intermittent regime, while making 216l of oxygen debt and spending 1,512g of glycogen and 1,080kcal.

Strength of alactate system

The speed of creatine phosphate (CP) degradation in leg extensors, i.e. the energy generation speed from CP, enables the monitored soccer player to run at the speed of 7m/s.

Capacity of alactate system

The quantity of CP in leg extensors enables him to run the distance of 51m in 7.2s. With 98-100% of maximal running speed in alactate regime during a game, the subject can run the distance of 1,275m.

Projected potentials

Projected strength of lactate system

The strength of the monitored subject is projected in such a way that he can run one minute at the maximal speed of 6.9m/s. He can cover the working distance of 396m in one minute at the speed of 6.6m/s, making an oxygen debt of 10 l/min and 70g of lactic acid, spending 50kcal and 70g of glycogen. According to forecast, during games, in intermittent regime, he can perform multiple repetitions of the said performance by engaging 90-100% of the projected lactate strength.

Projected capacity of lactate system

At the threshold speed of 6.9m/s, in one minute, he can make an oxygen debt of 22 liters and 154 grams of lactic acid, spending 110kcal and 154g of glycogen. In intermittent regime, per game, he can run a distance of 6,336m, making 330 liters of oxygen debt and spending 2,310g of glycogen and 1,650kcal.

Projected strength of alactate system

Projected speed for CP degradation in leg extensors, i.e. the energy generation speed from CP, enables the monitored soccer player to run at the speed of 9.2m/s.

Projected capacity of alactate system

The quantity of CP in leg extensors enables him to run the distance of 62m in 6.7s. With 98-100% of maximal running speed in alactate regime during a game, the subject can run the distance of 1,550m.

The evaluation of anaerobic status

During tests, the subject displayed unsatisfactory lactate efficiency, i.e. at lower speed equaling 6.1m/s he makes 40% more oxygen debt than he can make at the genetically projected speed of 6.9m/s. This means that, with an adequate training regime, he can improve lactate efficiency by 40%. He can improve the distance covered in intermittent regime by 24%. The results show that he functions with 90% of projected lactate strength and 81% of lactate capacity. Adequate training can help him improve lactate strength by 10% and lactate capacity by 19%, thus achieving the capacity speed of 6.9 m/s. The results show that he functions with 82.2% of alactate capacity. Adequate training can boost this performance by 17.8%, i.e. he can increase the amount of CP in leg extensors by 17.8%. The increase in the quantity of creatine phosphate in leg extensors, causes the increase in distance covered by running from 51m to 62m. He can increase the distance covered by running in alactate CP regime during a game by 22%. During tests, the subject worked with 76% of projected alactate strength. He can improve the energy generation speed, i.e. the speed of degradation for CP stored in leg extensors by 24% if adequate training is applied. Consequently, he can boost the threshold speed of running in alactate regime by 24%. The status in alactate and lactate strength and capacities in the case of monitored subject is below the values displayed by elite European and global offensive players. Nevertheless, his genetically projected lactate and alactate strength and capacities are above the current performance thresholds of elite offensive players and higher than lactate and alactate requirements of games played by elite teams by 67%. If adequate training is applied, the said results displayed by the subject can be elevated to or above the level currently displayed by elite europan and global offensive players and elite game requirements.

Status in speed

State

Maximal speed (flying start 20m) of the monitored subject equals 8.8m/s. Speed from high start at 20m equals 6.6 m/s.Speed from standing start, at 50m, equals 7.1m/s. Other characteristic of speed have already been presented in the estimate of his aerobic and anaerobic status and will not be repeated. The time necessary to establish movement equals 0.118s. The force necessary for establishing movement equals 680N. His ability to accelerate equals 5 index units (IU).

Projected potentials

The maximal speed of the monitored subject was projected at 10.5m/s. The speed from standing start at 20m was projected at 8.3m/s. The speed from standing start at 50m was projected at 8.8m/s. The time necessary to establish movement was projected at 690N. The projected value of the ability to accelerate equals 6.4 IU. All projected values relating to speed are at the current threshold of elite offensive players' performances.

Evaluation of status in speed

The result of the testing the maximum speed of the monitored subject can be improved by 16.2%, which means that the maximum speed he demonstrated in testing reaches only 83.8% genetically projected speed. Therefore, his natural, genetically conditioned, ability is to run 20 m from standing start in 1.9s at the speed of 10.5 m/s, instead of 2.27s at the speed of 8.8 m/s. The ability to accelerate can be improved by 20.5%, which means that, at the moment, it is at 79.5% of his genetically projected ability to accelerate. The projected results enable him to run the distance of 20m from standing start in 2.4 s, at the speed of 8.3 m/s, instead of 3.05s, at the speed of 6.6 m/s. He can improve the speed of running at 50m by 23.9%, which means that he is currently at 76.1% of genetically projected abilities. The projected value enables him to cover a 50m distance in 5.7s, at the speed of 8.8m/s, instead of 7.1s, at the speed of 7.1 m/s. The time necessary to establish movement is at 42% of genetically projected value which means that it can be improved by 58%, while the force necessary for establishing movement can be improved by 1.5%. If adequate training is applied, the said genetic projections of speed can be elevated to the level currently displayed by elite offensive players and elite game requirements.

Status in force

State

Isometric muscle work regime

In the case of the monitored subject, the maximal force in leg extensors in isometric regime equals 2,076.8 N. The subject generates this level of force in 1.672 s. The maximal force of certain groups (I, II, III, IV) of motor units in leg extensors equals: 10.9 N, 177.6 N, 202.1 N and 256.3 N. The maximal motor unit activation speed in leg extensors equals 4.48 IU and is achieved in 0.284 s. The maximal force generation speed in leg extensors equals 5,270 N/s. The maximal change in speed generation force in leg extensors equals 23,470 N/s. He can synchronize 91% of motor units in leg extensors during muscle work. The exponent, as a measure of intramuscular leg extensor coordination is 3.855, while the exponent for intermuscular coordination equals 2.932. The value of the first exponent tells us that intramuscular coordination is at the level of 95% of capacity value, while the second exponents tells us that the intermuscular coordination is at 90% of capacity value.

Muscle work in amortization regime In amortization (eccentric contraction) muscle work regime (drop jump amortization from 110m), the monitored subject is able to achieve the maximal force generation speed in leg extensors at 34,104 N/s in 0.131 s, at the angle of 125.28^0 and the level of force at 4,467.6 N and motor unit activation speed at 39.78 IU.

Reversible muscle work regime

In reversible regime during drop jump-depth jump from the elevation of 80cm, the subject's maximal force generation speed in leg extensors is at 72,518.6 N/s, s, while the time it takes them to transfer from eccentric to concentric contraction is at 0.086 s, the level of force is at 6,150.6 N, while the speed of motor units activation is at 51.72 IU. In shoulder muscles clean phase, his maximal force generation speed is at 13,888 N/s in 0.150 s, while the maximal speed of motor units activation is at 7.2 IU in 0.141 s and the maximal change in force generation speed is at 38,230 N/s. In half squat, his leg extensors' maximal force generation speed is at 18,892 N/s in 0.140 s, the maximal speed of motor units activation is at 12.9 IU in 0.138 s and the maximal change in force generation speed is at 42,000 N/s. His arm extensors in bench press achieve the maximal force generation speed at 11,721 N/s in 0.158 s, while the maximal speed of motor units activation is at 6.1 IU in 0.145

s and the maximal change in force generation speed is at 29,400 N/s. His back extensors in dead lift achieve maximal speed generation force at 7,038.7 N/s in 0.253 s, maximal motor unit activation speed is at 5.1 IU in 0.200 s and the maximal change in force generation speed is at 12,110 N/s.

The maximal weights lifted during the testing are: kettle bell clean 65 kg, half squat 120 kg, bench press 70 kg and dead lift 100 kg.

Concentric muscle work regime The maximal force generation speed in leg extensors in vertical standing jump equals 15,821 N/s with muscle unit activation speed at 6.2 IU and depth jump time at 0.250 s. At the moment, the subject is able to perform 42cm high jump.

Projected potentials

Isometric muscle work regime

In the case of the monitored subject, the maximal force in leg extensors in isometric regime is projected at 2,600 N in 1.324 s. The maximal force of certain groups (I, II, III, IV) of motor units in leg extensors was projected at: 22.2 N, 302.5 N, 487.1 N and 805.14 N. The maximal projected motor unit activation speed in leg extensors is projected at 6 IU in 0.121 s. The maximal force generation speed in leg extensors was projected at 44,555 N/s. The maximal change in speed generation force in leg extensors equals 23,470 N/s. According to projections he should be able to synchronize 98% of motor units in leg extensors during muscle work. The exponent, as a measure of intramuscular leg extensor coordination, is projected at 4.05, while the exponent for intermuscular coordination is projected at 3.22. All projected values relating to isometric force in the case of this subject are above the values achieved by elite soccer players.

Muscle work in amortization regime

In amortization (eccentric contraction) muscle work regime (drop jump amortization from 110m), the monitored subject is able to achieve the maximal force generation speed in leg extensors at 55,403 N/s in 0.109 s, at the angle of 113.6^0 and the level of force at 6,038.9 N and motor unit activation speed at 50.62 IU.

Reversible muscle work regime

In reversible regime during drop jump-depth jump from the elevation of 80cm, the subject's projected maximal force generation speed in leg extensors is at 104,799 N/s, while the time it takes them to transfer from eccentric to concentric contraction is at 0.077 s, the level of force is at 8,069.5 N, while the speed of motor units activation is at 60.1 IU. In shoulder muscles clean phase, his maximal force generation speed is projected at 19,840 N/s in 0.130 s, while the maximal speed of motor units activation is projected at 13.4 IU in 0.124 s and the maximal change in force generation speed is at 58,320 N/s. In half squat, his leg extensors' maximal force generation speed is projected at 27,781 N/s in 0.120 s, the maximal speed of motor units activation is projected at 21.9 IU in 0.128 s and the maximal change in force generation speed is projected at 70,000 N/s. His arm extensors in bench press are projected to achieve the maximal force generation speed at 16,280 N/s in 0.118 s, while the maximal speed of motor units activation is projected at 10.6 IU in 0.111 s and the maximal change in force generation speed is projected at 42,000 N/s. His back extensors in dead lift are projected to achieve maximal speed generation force at 9,642 N/s in 0.200 s, maximal motor unit activation speed is projected at 8.8 IU in 0.132 s and the maximal change in force generation speed is projected at 16,600 N/s. The maximal projected lifting weights for the monitored subject are: kettle bell clean 100 kg, half squat 200 kg, bench press 110 kg and dead lift 160 kg.

Concentric muscle work regime

The maximal projected force generation speed in leg extensors in vertical standing jump equals 21,801 N/s with muscle unit activation speed at 9.1 IU and depth jump time at 0.157 s, which enables him to perform a vertical jump of 81cm.

All projected values of force and its dimensions, for all monitored muscle group, in isometric and dynamic regime, in the case of monitored subject, are above the current threshold of elite soccer players.

Evaluation of status in force

Isometric muscle work regime

The subject is able to increase the maximal force of leg extensors by 25.6%. He can improve the maximal speed of motor units activation by 33%. The time necessary for generating maximal force can be decreased by 26.2%, while the time necessary for motor units activation speed can be reduced by 234%. He can increase the maximal force of certain groups of motor units from 70-314%. He can improve the maximal force generation speed by 261%, maximal change in force generation speed by 90%, motor units synchronization by 7%, intramuscular coordination by 5% and intermuscular coordination by 10%.

Amortization muscle work regime

In amortization regime, the monitored subject can increase the maximal force generation speed in leg extensors by 60%, decrease amortization time by 20%, and boost the motor units activation speed by 30%.

Reversible muscle work regime

In reversible regime (drop jump-depth jump from the elevation of 80cm) the monitored subject can increase the maximal force generation speed by 40%, decrease the time it takes to switch from eccentric to concentric contraction by 11% and increase the motor units activation speed in leg extensors by 19%. Weight lifting can help him to increase the maximal force generation speed from 27% to 32% depending on muscle group, decrease the time it takes to generate force and lower the motor units activation speed from 7% to 34%, as well as to increase the maximal change in force generation speed between 37% and 67%, also depending on muscle group. The weights lifted during testing can be increased 1.54 times in kettle bell clean, 1.67 times in half squat, 1.57 times in bench press and 1.6 times in dead lift.

Concentric muscle work regime

In concentric regime, the subject can increase the maximal force generation speed by 37%, decrease the drop jump time by 60%, increase the motor units activation speed in leg extensors by 50% and the height of vertical depth jump by 1.93 times. In the end we can conclude that the current level in force allows the monitored subject to play games using 40-95% of the projected potentials, which is mostly below the requirements of games. Nevertheless, his potentials are above the requests of games when it comes to force.

Training performance programming

One of the basic features of this model is software programming and the selection of training with the best possible effect on soccer games for periods of 30 days (Milosevic, 2010a, 2012, 2013). In continuation, the authors will present 1 aerobic, 1 lactate and 1 force training. The first two trainings were programmed on initial data, while the force training was programmed on estimated performance data after three training cycles aimed at force generation speed enhancement.

In order to increase aerobic training performance and aerobic performance during soccer games by 8-17% in comparison to initial data, he has to spend 1,249.02l of oxygen and 6,245.1kcal, as well as to generate force ranging from 33,763 N to 46,562 N per training. In order to achieve the planned effects and performance he has to run 94.49km at the speed ranging from 3.54 m/s to 4.66 m/s in 6.7 h. The trainings should be distributed 5 times a week over 4 weeks, while each training should last 20min. Aerobic strength used in trainings ranges from 2.85 l/min to 3.7 l/min, that is from 14.245 kcal/min to 18.5 kcal/min.

In order to increase lactate training performance and lactate performance during soccer games from 7% to 20%, in comparison to initial data, the subject is supposed to spend 12,620.8 grams of glycogen, generate 54,432 N of force, 1,792l of oxygen debt and 12,620.8g of lactic acid in leg extensors. In order to achieve the planned effects and performance, he is supposed to run 46.848km at the speed of 6.1m/d in 2.13h of running. The trainings should be distributed 2 times a week over 4 weeks. During one training he should perform 4 series with 4 repetitions. During each repetition, he should cover the distance of 366m in 1 minute. Breaks between repetitions are 3, 2.5 and 2 minutes, while rest between series should last 8 minutes. Lactate strength used to perform repetitions in a serie equals 88.5kcal/min.

In order for the monitored subject achieve a 19% increase in force generation speed in leg extensors by lifting weights in half squat, in comparison to the results of the fourth measuring, in each half squat he has to achieve force generation speed in leg extensors at 21,780 N/s, with motor units synchronization at 95% and motor units activation speed at 16.6 IU. In addition, he has to generate 610,000 N of force, 76.8 kW of power and spend 1,080 kcal of energy. In order to achieve the planned effects and increase force generation speed by 5,278.4 N/s the subject has to perform 200 half squats with repetition speed at 1.74 m/s over 16 minutes, while lifting 28,000 kg of weight. The trainings should be distributed 2 times a week over 4 weeks. During one training, he should perform 5 series of 5 repetitions lifting 80% of RM, i.e. 140kg. The time of weight lifting in half squat equals 2 minute per training. Breaks between series should last 3 minutes. After the first exercise, he should always perform an exercise aimed at another muscle group. The training is programmed for 6 muscle groups (3 pairs of exercises). He first has to perform all series and repetitions from the first pair and then switch to the second and, finally, to the third pair of exercises at the end of the training. Due to this paper, we have only presented the programming of training performance for force generation speed in leg extensors. In the same way the training can be programmed for other muscle groups and dimensions.

Discussion

The application of the proposed model enabled the authors to perform a general state evaluation for the monitored subject's genetic potentials, to predict the development of his physical status and to calculate the necessary work and speed of execution he can display during a game. The evaluation of output and usefulness of the offered model was also performed by using dimensions that describe the physical status of elite soccer players and their performance at European championships and champions league (Hoff, 2005; Bangsbo et al., 2006; Milosevic et al., 2012a; Osgnach et al., 2010; Reilly, 2007). In order to do the abovementioned, the authors used the following experimental data. On average, during a game, elite soccer players, in different systems of game, cover the distance of 10.2km. On that occasion they use sprints in intermittent acceleration, decelerations, change the direction of their movement, perform turns and run slowly. All this time, leg extensors generate the necessary level of force in eccentric, concentric and reversible regime. The duration of contact between their feet and surface when running ranges from 0.075 to 0.100 seconds, while, in the case of jumping, the contact lasts 0.170s from the beginning of leg extensor contraction. While performing the said movements, they spend more than 1,500 kcal of energy, 159 liters of oxygen in aerobic regime, 1,120 grams of glycogen. They make 160 liters of oxygen debt and 1,120 grams of lactic acid in lactate regime while running. On average, in aerobic regime, they run the distance of 5.42 km, spending 795kcal; in lactate regime they averagely run the distance of 3.8km, spending 555.4kcal; in alactate regime, they averagely run 0.98km, spending 150.3kcal. Their average aerobic energy strength is at 17.7kcal/min or 0.23 kcal/min/kg per kilo of body weight and average running speed of 15km/h during games. The maximal running speed achieved by elite soccer players in lactate regime during games is 24.84km/h (Bangsbo et al., 2006; Milosevic et al., 2012a; Osgnach et al., 2010). Their speed of lactate energy production equals 135 kcal/min (Milošavić et al., 2012a; Osgnach et al., 2010; Reilly, 2007; Stølen et al., 2005).

The maximal recorded speed of running in alactate regime during games is 33.47 km/h (Milosevic et al., 2012a; Osgnach et al., 2010; Reilly, 2007). The maximal speed of energy generation speed in ATP regime during games is 600 kcal/min, while it equals 400 kcal/min in CP regime (Bangsbo et al., 2006; Milosevic et al., 2012a; Reilly, 2007). Their average maximal oxygen consumption is 5.25 l/min, relative at 69 ml/kg/min, achieved with the average running speed at 5.2 m/s. During one performance they can make 15l of oxygen debt and 105grams of lactic acid, at the speed of 6.9 m/s, and spend 105g of glycogen. The average maximal force in leg extensors is 3,463N with maximal motor units activation speed at 5.74 IU in 0.162s with the force of 1,731N and force generation speed at 10685.2 N/s (Hoff, 2005; Bangsbo et al., 2006; Milosevic, 2010b; Reilly, 2007). Based on the described external criterion and results on state, potentials and development rules for the monitored subject, having in mind the same way of expressing data and accuracy of calculations, it is possible to directly predict his level in comparison to game requirements and elite soccer players' performances. Namely, most initial results of the monitored subject is below the current performance threshold of elite soccer players and the requirements of their game. The rules of development and genetically projected potentials prove that the subject can develop these properties through training and exceed the mentioned level. The same dimensions can be used for performing an early selection of future soccer champions, which highly recommends this model as very useful in this domain (Milosevic, et al., 2012b; Tucker and Collins 2012). At the moment when the monitored subject reaches 90% of his potentials and maintains this level with adequate trainings, he will be able to sustain the strictest tactical demands his trainer sets for attackers at games with irregular weekly distribution without a drop in performance due to fatigue, during the whole season and equally as elite soccer players.

The output data presented by Bompa, Kurelic, Zatsiorsky and other similar models (Bompa, 2001; Kurelic et al., 1975; Zatsiorsky, 1970) and the data that describe the game cannot be directly compared. Their data in endurance, speed endurance, long and short term muscle endurance and the data on other types of endurance, then strength, explosive strength, coordination, agility and dexterity are expressed in different measures than the data that describe dynamic and functional requests of games generating a need for indirect establishing of the degree of their concordance by applying correlation, regression, canonic and factor analyses. By using their data it is not possible to directly program training effects, changes and training work in accordance with the dimensions used to describe soccer games. Nevertheless, the data on the monitored subject on aerobic and anaerobic status, status in speed and force, are compatible with the data coming from functional analyses of soccer games and there is no need for statistical methods aimed at determining the nature and level of their connection. They can be used to directly quantify training goals, training effects, changes and work, using the said software, for one or more trainings in the domain of aerobic and anaerobic status, status in speed and force, in accordance with dimensions used to describe soccer games (Milosevic, 2004, 2010a,b, 2013). Based on the output data on aerobic and anaerobic status, the software can be used to calculate how many calories, oxygen and glycogen the subject can spend in different regimes, how much lactic acid can he produce and tolerate, how fast is his recovery rate, how long he can run, and how many times he can run a distance using different energy sources, which is impossible with data on different types of endurance used in other models (Milosevic, 2004, 2010a,b, 2013). Output data on force can be used to make software-based forecasts and projections on the time the subject needs to run certain speed or speeds during a game, how long he takes to establish movement, accelerate, decelerate, change direction or perform a certain jump via speed and change in force generation speed, the speed of activation, synchronization and optimization of work of motor units in eccentric, concentric and reversible regime in leg extensors (Milosevic, 2004, 2010b; Milosevic et al., 2000, 2004). In contrast to other models, the proposed model produces data that reflect the soccer players' success in realizing their potentials, what percentage of their potentials are they currently using when playing a game, how far they can develop each of the abilities described, and what are the differences among them when it comes to performance threshold and genetically projected potentials. This model incorporates non-linear mathematical functions of different type that can be used to vary the monitored variables in time and under the influence of adequate trainings (Milosevic, 2004, 2010a,b, 2012; Milosevic & Milosevic, 2013; Milosevic et al., 2000, 2004, 2012b). All of the abovementioned data enabled the authors to conclude that the monitored subject has the potential to improve his performance from 5-314% within 2 to 8 months. The proposed model has hardware-software support for acquiring and analyzing data, determining test variables and programming training effects, changes and training work.

The programming is performed directly by using output data from the model (Milosevic, 2004). Namely, according to defined goals and rules of development, different types of trainings are programed especially for each individual. Also, changes and effects they cause (the speed and quantity of generated energy, oxygen debt and lactic acid, the quantity of spent and re-synthetized glycogen, distances covered by running, the length of breaks, active training time, recovery speed, etc.) are simulated and analyzed for each person independently and compared to game requirements or threshold values of performances and abilities of each person (Milosevic, 2004, 2010a,b; Milosevic et al., 2012a,b). Based on the efficiency of goal accomplishment and concordance between achieved training effects and changes with game requirements, threshold values or desired competition results (Bangsbo et al., 2006; Milosevic et al., 2012a; Osgnach et al., 2010), the software chooses the most efficient training for each subject, which is impossible achieve with output data generated by other models. Good external exploitation of output data, explication of cause and consequence relations between physical status and soccer performance, hardware-software support, generation of data that are provided or cannot be provided in vivo, as well as other characteristics, recommend the proposed model for everyday use in coaching practice.

Conclusions

The paper proposes a complex model of excellent metric characteristics, that describes and evaluates aerobic and anaerobic status, status in speed and force for state variables, genetic potentials, development functions, forecasts and programming of training and sports performance of soccer players. The behavior and characteristics of this model are presented through the results of a talented soccer player. A certified hardware-software system was used for measuring and evaluating all variables, calculations, analysis, forecasts and programming of training and soccer performance.

The initial results of the monitored subject were below the current threshold of performances displayed by elite soccer players and requirements of elite soccer matches. According to the rules of development and genetically projected potentials, he can train to boost his performance to match or even exceed the said threshold and requirements in 8 months. Output data from this model are directly used for selecting and quantifying training goals, programming training effects changes and training work. Besides, they can be used to compare the level of performances of subjects in question to performance threshold of elite soccer players, as well as to the projected threshold of their own potentials. They point to the relation between elite and champion performances and the threshold of a subject's projected potentials, about the level of projected possibilities they can use in a soccer game, the progress they can make within certain ability and what are the differences among soccer players when it comes to their maximal potentials. In contrast to models used only for evaluating the state, all of the abovementioned characteristics for the proposed model enable users to manage the training and sports achievements and represent a huge advantage in everyday coaching.

References

Bangsbo, J,, Mohr M, Krustrup P. (2006): Physical and metabolic demands of training and match-play in the elite footvall player. *Journal of Sports Sciences*, *24*(7): 665 – 674.

Bobbert, M. F., Gerritsen, K. G., Litjens, M. C., Van Soest, A. J. (1996): Why is countermovement jump height greater than squat jump height? *Medicine and Science in Sports and Exercise,* 28: 1402-12.

Bompa, T. O. (2001): *Periodization – Training for Sports*. US: Champaing, IL. Human Kinetiks.

Clarce, M. M. (1956): *The aplication of Measurements to Health and Physical Education*. New York: Prentice-Hall.

Hoff, J (2005): Training and testing physical capacities for elite soccer players. *J Sports Sci*., 23(6):573-82. Kurelić, N., Momirović, M., Stojanović, M., Šturm, J., Radojević, Đ., Viskić-Štalec, N. (1975): *Structure and development of morphological and motoric dimensions in the youth population*. Belgrade: FFV Institute for Scientific Research.

Milosevic BM, Blagojevic M, Pilipovic S & Tosic B. (2000): The muscle contraction and the force production. Proceedings of the *XVIII Iinternacional symposium of biomechanics in sport* (pp. 183-186). Hong Kong.

Milošević, B.M. (2004): *Software package for diagnostics, programming and control of training in elite athletes*. Belgrade: Police College.

Milosevic, B.M., Mudric, R., Dopsaj, M., Blagojevic, M. and Papadimitriou, E. (2004): The control of force creating in function of the muscle contraction intensity. Edited by: Kellis, E., Amiridis, I and Vrabas., I. In: Book of Abstracts of the *4th International Conference on Strength Training* (pp. 320-321). Serres, Greece: Aristotle University of Thessaloniki, Department of Physical Education and Sport Science at Serres.

Milošević, B.M. (2010a): Programming, analysis and evaluation of the training practice: increasing speed and quantity of anaerobic lactate energy generation, speed of recovery and running velocity in lactate regime of work in professional soccer players according to traditional and modern training technology. *Serb J Sports Sci.,* 4(3):119-125.

Milošević, B.M. (2010b): *Physical preparation of elite athletes: standardization of management processes*. Belgrade: APP.
Milosevic B.M.(2012): Model for building energy profiles of top soccer players. *Fudbalski kod*, 2:51-56.
Milošević, B.M., Milošević, M.M & Yourkesh, M. (2012a): Funnctional analysis of soccer game. *Euro. J.Sports Exerc. Sci*., 1(3):77-84.
Milošević, M.M, Mudrić, M., Mudrić, R & Milošević, B.M. (2012b): Using the mind in reprogramming the limits of muscle force in the process of creating champions. *Sport-science & practice,* 2(5): 39-58.
Milošević, B.M, & Milošević, M.M. (2013): *Special Physical Education: scientific basis*. Belgrade: CEDIP
Milosevic B.M. (2013): The Analysis of Limitations Created by Using Sports Form When Coaching Professional Soccer Players and Educating Coaches. Serbian Journal of Sports Sciences. In press.
Osgnach, C., Poser, S., Bernardini, R., Rihaldo, R. and Di Prampero, P. (2010). Energy Cost and Metabolic Power in Elite Soccer: New Match Analysis Approach. *Med. Sci. Sports Exerc.,* 42(1):170-178.
Reilly, T. (2007): *The science of training – soccer: A Scientific Approach to Developing Strength, Speed and Endurance.* New York: Routledge.
Stølen, T., Chamari, K., Castagna, C. and Wisloff, U. (2005): Physiology of soccer: an update. *Sports Medicine,* 35 (6): 501-536.
Tucker R, Collins M. (2012): What makes champions? A review of the relative contribution of genes and training to sporting success. *Br J Sports Med*.; 46:555–561.
Zatsiorsky, V. M. (1970): *Fizičeskije kačestva sportsmena*. Moskva: Fiskuljtura i sport.