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Security Dimensions. International & National Studies nr 4 (24), 94-104

2017

SECURITY DIMENSIONS
INTERNATIONAL & NATIONAL STUDIES
NO. 24; 2017 (94–106)
DOI 10.24356/SD/24/5

CONCENTRATION OF PHOSPHORUS IN THE BLOOD OF YOUNG MEN AGED 18–21 AS AN INFORMATIVE BIOCHEMICAL MARKER FOR ASSESSING ADAPTATION PROCESSES IN STRENGTH FITNESS

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ABSTRACT

The results of the research concerning further solution of the problem of finding informative markers for the diagnostic of the youth functional state which will allow to comprehensively evaluate the efficiency of the mechanisms for optimizing the training process in strength fitness are represented in this article. Two groups of young men aged 18 to 21 years participated in the research. Each group used our models of training for 3 months. The models differed significantly in terms of amount and intensity of loads. The results indicate that despite the use of sufficiently high parameters of loading intensity by the participants of the basic group under the experimental model of training, we have got a significant increase in their strength possibilities by 33.1% and their body girth parametres by 11.7% compared with the initial data. The dynamics of similar indicators fixed among the representatives of the control group also shows growth but almost twice less. At the same time, the results of monitoring the concentration of phosphorus in serum of the examined contingent, which plays an important role in energy metabolism during the process of muscle activity and reflects the mechanisms of oxidative phosphorylation, enable us to assume that the most pronounced adaptive changes in the organism during this training process are found in a group of people who have used the experimental model of fitness. This model is based on the mechanisms of reducing the duration of rest between the sets and the number of repetitions that affected the total amount of loading.

ARTICLE INFO

Article history
Received: 10.11.2017 Accepted 17.12.2017

Key words
phosphorus concentration, adaptive changes, intensity and amount of loading, strength fitness, strength possibilities

Statement of the problem

The modern system of sports training necessitates entirely new mechanisms for optimizing the training process which will make it possible to constantly increase athletes' performance. They will improve the adaptive capacity of an athlete's body and will not use short-term, sometimes almost critical, compensatory reactions. Not only specialists in physical education and sports are engaged in solving this problem, but scientists in the fields of biology and medicine also pay great attention to this issue in order to study the changes in functional systems of the human body under the influence of stressors, including physical activity[1].

[1] F. Meerson, *Adaptation to stress and physical loading*, Meditsina, Moscow 1988; A. Chernozub, *Peculiarities of men's adaptation reactions under strength loading*, "Physiological Jour-

It is known that with the increase in the athletes' fitness level, the growth rate of their morpho-functional indicators will be slowed down and, accordingly, the dynamics of further improvement of efficiency will also decrease[2]. In order to solve this problem, the vast majority of specialists in strength sports[3] use the most popular and well-known principle of constantly increasing the weight of the sports equipment (barbells, dumbbells etc.). This method significantly increases the amount of training loads. They sometimes use a certain combinations of exercises. At the same time, the main indicators for assessing the efficiency of any training program are the development of strength abilities, increase in morphometric body parameters and heart rate data[4]. Adaptive or compensatory reactions in the body of athletes occured in response to the training of different levels and intensity are not studied and, moreover, not used by trainers and scientists in the process of monitoring the training process and during its optimization[5].

One of the important criteria for assessing the adequacy of loading to functional possibilities of the human body is the index of inorganic phosphorus concentration in serum. It plays an important role in energy metabolism in the process of muscle activity and reflects the mechanisms of oxidative phosphorylation[6].

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nal", 2015, 61 (5), p. 99–107; A. Chernozub, *Integral method for determination of optimal safe methods of physical activity for servicemen at training and battle actions*, "European International Journal of Science and Technology", 2015, 4 (7), p. 8–11; A. Philippe, *Modeling the responses to resistance training in an animal experiment study*, "Biomed Res Int", 2015, p. 914–960.

[2] F. Meerson, *Adaptation to stress and physical loading*, Meditsina, Moscow 1988; A. Chernozub, *Peculiarities of cortisol level changes in the blood of athletes and untrained boys in response to heavy power training loads*, "European International Journal of Science and Technology", 2013, 2 (9), p. 52–57.

[3] A. Chernozub, *Integral method for determination of optimal safe methods of physical activity for servicemen at training and battle actions*, "European International Journal of Science and Technology", 2015, 4 (7), p. 8–11; K. Goto, *Hormonal and metabolic responses to slow movement resistance exercise with different durations of concentric and eccentric actions*, "Eur J Appl Physiol", 2009, 106 (5), p. 731–739.

[4] F. Meerson, *Adaptation to stress and physical loading*, Meditsina, Moscow 1988.

[5] A. Chernozub, *Peculiarities of men's adaptation reactions under strength loading*, "Physiological Journal", 2015, 61 (5), p. 99–107; A. Chernozub, *Peculiarities of cortisol level changes in the blood of athletes and untrained boys in response to heavy power training loads*, "European International Journal of Science and Technology", 2013, 2 (9), p. 52–57.

[6] F. Iordanskaya, *Mineral exchange in the system of monitoring the functional preparedness of highly qualified athletes*, Sovetskiy sport, Moscow 2014; F. Iordanskaya, *Diagnostic*

Analyzing the results of the research covered in available scientific literature[7], it was discovered that increase of phosphorus concentration in athletes' blood in response to training loads (in most cases aerobic ones) indicates the decomposition of phosphorus compounds and the reduction of ATP resynthesis speed. At the same time, the increase of this biochemical index of blood in response to a physical stimulus reflects inhibition of oxidative phosphorylation[8]. Accumulation of inorganic phosphorus in response to physical activity has a direct oppressive effect on the "excitation-reduction" process and increases the concentration of lactate and hydrogen ions and, accordingly, leads to muscle fatigue[9].

The main objective of the research is to study the changes in phosphorus concentration in blood serum of boys aged 18–21 under different models of training exercises in strength fitness and to determine the degree of efficiency of using this biochemical indicator as one of the informative markers for assessing adaptive changes in the body and indicator of control of training activity optimization.

Connection of the study with scientific programs, plans, themes

The article is a fragment of the scientific work "Protective, adaptive and compensatory reactions of the human body in the process of loading in strength sports" (State Registry No. 0112U005261).

Material, research methods

We examined 50 healthy boys aged 18 to 21 years who had not previously been engaged in fitness and other sports. Taking into account the purpose and tasks of the study, two experimental control and basic groups were formed.

and prognostic value of microelements of blood in monitoring the functional preparedness of highly qualified athletes, OOO «Skayprint», Moscow 2013.

[7] F. Iordanskaya, *Mineral exchange in the system of monitoring the functional preparedness of highly qualified athletes*, Sovetskiy sport, Moscow 2014; F. Iordanskaya, *Diagnostic and prognostic value of microelements of blood in monitoring the functional preparedness of highly qualified athletes*, OOO «Skayprint», Moscow 2013; A. Philippe, *Modeling the responses to resistance training in an animal experiment study*, "Biomed Res Int", 2015, p. 914–960; D. Plews, *Training adaptation* and heart rate variability in elite endurance athletes: opening t*he door to effective monitoring,* "Sports Med", 2013, 43 (9), p. 773–781.

[8] F. Iordanskaya, *Mineral exchange in the system of monitoring the functional preparedness of highly qualified athletes*, Sovetskiy sport, Moscow 2014.

[9] F. Iordanskaya, *Diagnostic and prognostic value of microelements of blood in monitoring the functional preparedness of highly qualified athletes*, OOO «Skayprint», Moscow 2013.

Members of the control group for three months were using the "universally accepted" model of training programs in strength fitness[10]. Members of the basic group used a completely different model of muscle activity compared with the "universally accepted" one: the number of repetitions in the set decreased from 10 to 4; the rest time between the sets decreased from 1 minute to 40 seconds; the speed of exercise was slowed down from 6 seconds to 9 seconds during the concentric and eccentric phases of motion, and the total amount of training decreased by 40%. Exercises were performed with a barbell, dumbbells and on exercise machines following the technology we had set. The duration of one training was no more than 40 minutes regardless of muscle activity models used by members of the groups. Trainings took place three times per week.

All participants had passed the medical tests and biochemical laboratory control (16 indicators). The results showed they had no medical contraindications for participation in the research.

Studying the indicators of development of maximum muscular strength and body girth parameters occurred during three months going in for strength fitness using well-known methods[11]. The control examination was conducted every month.

Laboratory examination of blood serum on the concentration of phosphorus was carried out before and immediately after the training session in several stages: before the experiment and after three months of systematic training in strength fitness. The concentration of phosphorus in the blood of the participants was determined using the spectrophotometer StatFax 4700 (USA) in a certified medical laboratory.

Statistical processing of the results was carried out using the statistical software IBM * SPSS * Statistics 21. The methods of parametric statistics with the help of the Student's t-test as well as the methods of non-parametric statistics using the Wilcoxon rank-sum test were used.

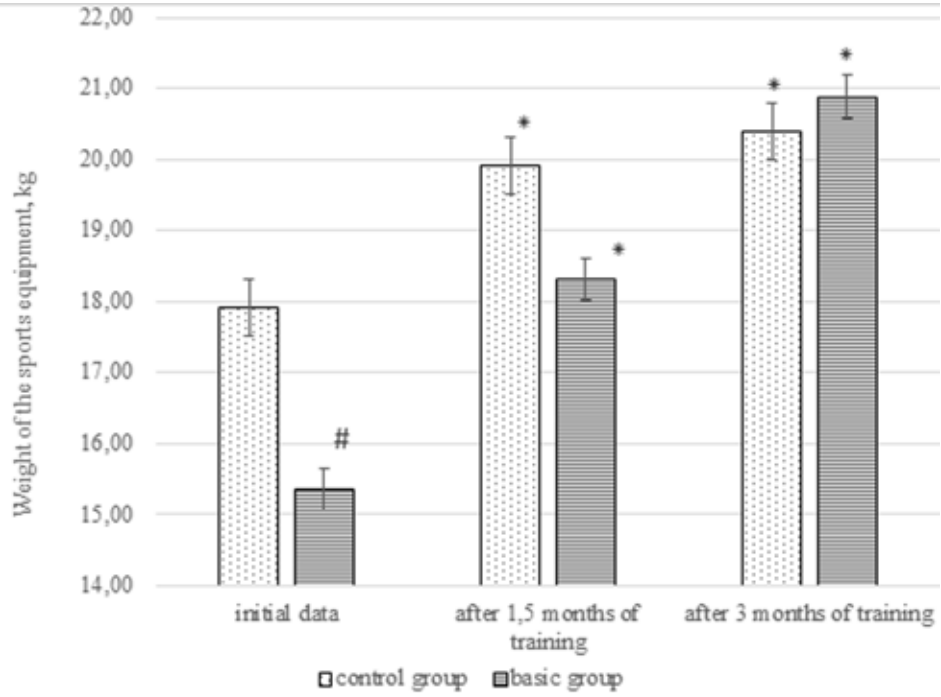
[10] A. Chernozub, *Peculiarities of cortisol level changes in the blood of athletes and untrained boys in response to heavy power training loads*, "European International Journal of Science and Technology", 2013, 2 (9), p. 52–57.

[11] A. Chernozub, *Integral method for determination of optimal safe methods of physical activity for servicemen at training and battle actions*, "European International Journal of Science and Technology", 2015, 4 (7), p. 8–11; K. Goto, *Hormonal and metabolic responses to slow movement resistance exercise with different durations of concentric and eccentric actions*, "Eur J Appl Physiol", 2009, 106(5), p. 731–739; R. Kraemer, *Endocrine alterations from concentric vs. eccentric muscle actions: a brief review*, "Metabolism", 2015, 64 (2), p. 190–201.

Results of the research and their discussion

The results of studying the changes in the strength possibilities of the participants from two groups during the exercise "lifting dumbbells on biceps in the standing position" established during 3 months of systematic going in for strength fitness with the use of our models of training are presented in Fig. 1.

Fig. 1. Change in the indicators of the maximum muscular strength of the participants during the exercise "lifting dumbbells on biceps in the standing position" using different models of strength fitness training for 3 months, n = 50



Note: * -p <0.05 compared to the previous month's figures; # -p <0.05 compared to the figures fixed in another group of boys

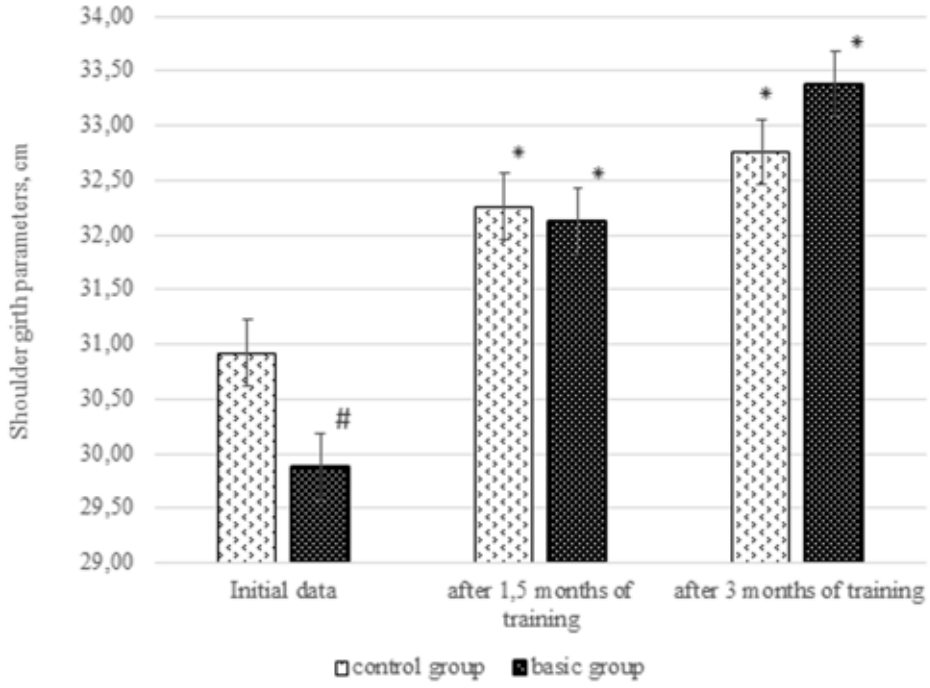
Results got at the beginning of the study indicated that the primary level of physical training, namely the level of strength possibilities, was different. Parameters of the controlled indicator among the boys of the basic group are lower by 8.7% (p <0.05) than the data set in the control

group. This circumstance is due to the use of a random sample method in the process of dividing participants into groups.

In turn, controlled indicators demonstrate significant growth by 39.0% ($p < 0.05$) during the experiment among the representatives of the basic group compared to the initial data. At the same time, the indicators of the strength possibilities of the control group members during the experiment also show a positive dynamics of only 21.7% ($p < 0,05$) compared with the initial data which significantly differs from the results of the opponents.

Thus, the obtained results indicate that an experimental model of training sessions based on mechanisms of reducing the amount of training work by increasing the level of loading intensity more positively affects the growth of the indicators of maximum muscle strength of the basic group participants.

Fig. 2. The dynamics of shoulder girth parameters of the boys in the conditions of different models of strength fitness training for 3 months, n = 50



Note: * -p <0.05 compared to the previous month's figures; # -p <0.05 compared to the figures fixed in another group of boys

Evaluating the results of the growth of the training work amount, the quantity of which depends on the level of strength possibilities of certain muscle groups and the physical condition of the human body in general, simultaneously arise controversial questions about the influence of the proposed model of training on the morphometric parameters of the body (body girth parametres).

The results of studying peculiarities of the changes of the body girth parameters (on the example of the shoulder girth parameters) of the participants from both groups fixed for 3 months strength fitness with the use of our models of training are presented in Fig. 2.

An analysis of the results obtained at the beginning of the study suggested that the primary (before the experiment) level of morphometric parameters of the body was different. Thus, shoulder girth parameters of the boys of the basic group were lower by 3.4% ($p < 0,05$) compared with the control group.

In turn, the morphometric indices we investigate show a significant increase by 11.7% ($p < 0.05$) for 3 months of the experiment among the representatives of the basic group compared to the initial data. Indicators of the shoulder girth parameters of the control group also show a positive dynamics of only 5.9% ($p < 0,05$) compared with the original data which significantly differs from the results of the opponents.

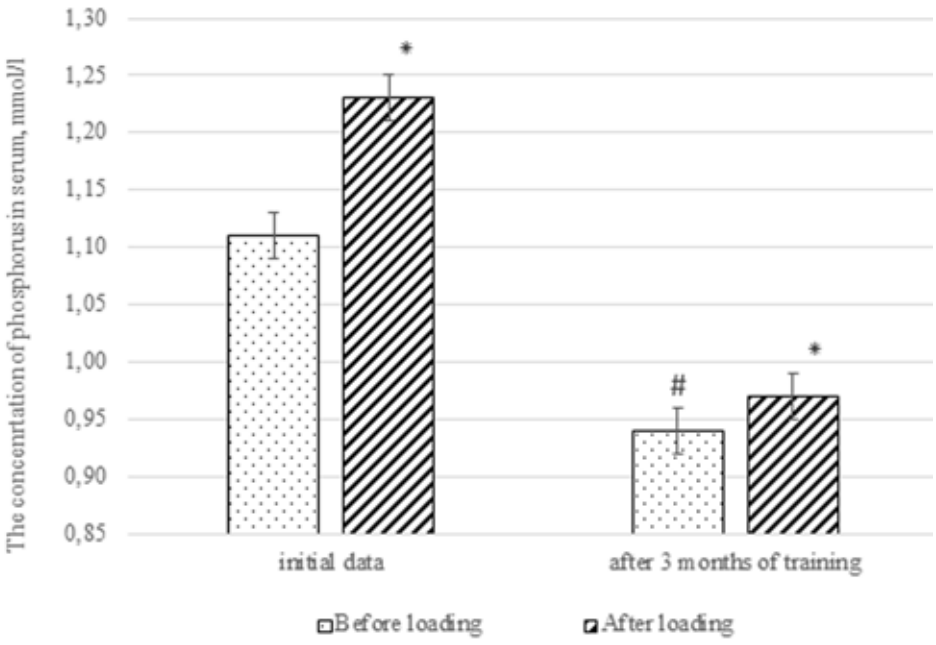
At the same time, it is known that short-term positive changes in the organism shown up through the growth of strength possibilities and improvement of morphometric parameters do not really reflect the increase of their adaptive capacity[12]. However, we should remember that short-term (no more than for three months) manifestations of accelerated efficacy may occur due to compensatory reactions of the organism to a physical irritant. Further use of the proposed amount and intensity of loading will activate the processes of disadaptation, rather than adaptation[13].

[12] A. Chernozub, *Peculiarities of cortisol level changes in the blood of athletes and untrained boys in response to heavy power training loads*, "European International Journal of Science and Technology", 2013, 2 (9), p. 52–57; A. Chernozub, *Integral method for determination of optimal safe methods of physical activity for servicemen at training and battle actions*, "European International Journal of Science and Technology", 2015, 4 (7), p. 8–11.

[13] A. Lopatina, *Theoretical aspects of changing biochemical blood indicators of athletes as an indicator of adaptation processes*, "Pedagogical-psychological and medico-biological problems of physical culture and sports", 2014, 2 (31), p. 117–122; A. Chernozub, *Peculiarities of men's adaptation reactions under strength loading*, "Physiological Journal", 2015, 61 (5), p. 99–107.

The concentration of phosphorus in serum of young men from both groups in the process of using different models of strength fitness training is presented in Fig. 3 and 4.

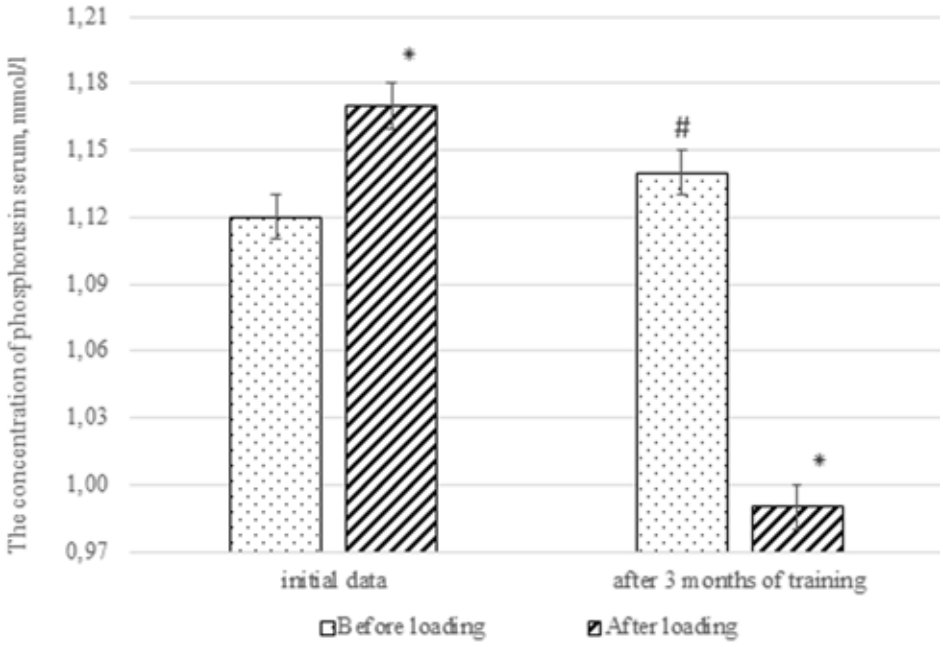
Fig. 3. Changes in concentration of phosphorus in blood serum of boys from the control group during 3 months going in for strength fitness with the use of different models of training, n = 25



Note: * -p <0.05 compared to the indicators before loading; # -p <0.05 compared to the results set at the beginning of the study

Analysis of the results established at the beginning of the study shows that after strength training the concentration of phosphorus in serum of the control group increases by 10.8% (p <0.05) compared to the state of rest (Fig. 3). This tendency was observed after three months of using this model of training by the young men of this group but with less growth (only by 3.1%) despite the fact that the indicators of maximum muscular strength and the amount of loading exceed the results, fixed at the beginning of the research, almost twice.

Fig. 4. Changes in concentration of phosphorus in blood serum of boys from the basic group during 3 months going in for strength fitness with the use of different models of training, n = 25



Note: * -p <0.05 compared to the indicators before loading; # -p <0.05 compared to the results set at the beginning of the study

Similar results are described during the control of the energy supply system of athletes in the conditions of prolonged loading on bicycle ergometer. They indicate that this biochemical parameter increases in response to physical activity due to the decomposition of phosphorus compounds and decrease in the ATP resynthesis rate[14].

Analyzing the tests results of the basic group, it is discovered that phosphorus shows completely opposite changes of both basal level and in response to extreme loading after three months of using the experimental model of strength fitness training compared with the data of the control

[14] F. Iordanskaya, *Mineral exchange in the system of monitoring the functional preparedness of highly qualified athletes*, Sovetskiy sport, Moscow 2014; F. Iordanskaya, *Diagnostic and prognostic value of microelements of blood in monitoring the functional preparedness of highly qualified athletes*, OOO «Skayprint», Moscow 2013.

group representatives. However, at the beginning of the study, we have observed a slight increase in the concentration of phosphorus in the blood serum of young men from the basic group by 4.4% ($p < 0.05$) compared to the state of rest (Fig. 4).

In turn, after 3 months of using the experimental model of training by the participants of the research, it was established that the index of phosphorus concentration in serum shown a decrease in response to the given physical irritant by 13,2% ($p < 0,05$) compared with the state of rest. This fact, in our opinion, indicates that the reduction of this biochemical indicator after intensive strength training can be caused by the mechanisms of oxidative phosphorylation. We assume that there happens an active process of phosphorylation that is an evidence of a significant adaptation of the organism to this physical activity due to the transition to a more economical energy supply system.

Conclusions

1. The results indicate that despite the use of sufficiently high parameters of loading intensity under the experimental model of training boys at the age of 18 to 21 years have got a significant increase in their strength possibilities by 33.1% and body girth parametres by 11.7% compared with the initial data. The dynamics of similar indicators fixed among the representatives of the control group also shows growth but almost twice less.
2. The results of monitoring the concentration of phosphorus in serum of the examined contingent, which plays an important role in energy metabolism during the process of muscle activity and reflects the mechanisms of oxidative phosphorylation, enable us to assume that the most pronounced adaptive changes in the organism during this training process are found in a group of people who have used the experimental model of fitness. This model is based on the mechanisms of reducing the duration of rest between the sets and the number of repetitions that affected the total amount of loading.
3. The experimental model of training has a more positive effect on the growth of maximum muscular strength and body girth parameters compared with a large amount of loading that is inherent in the "standard" models of muscular activity.