The variation in the strength of the field during the shuttle's motion

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Abstract

Objective of the study was to calculate the concentration of the force field in which the athlete's center of mass shifts during the shuttle run.

Methods and structure of the study. The researchers captured footage of two athletes performing shuttle drills: a jiu-jitsu master (weighing 52 kilograms and standing at 1,6 meters) and a novice athlete (weighing 30 kilograms and standing at 1,2 meters). For each athlete, the path of the center of gravity was plotted for one oscillation of the center of gravity (for one forward and backward movement), and the values of the projections of the velocities and accelerations of the centers of gravity on the coordinate axes were calculated.

Results and conclusions. The differences in the force fields of a highly trained athlete and a beginner athlete were examined. The experiment revealed that the periods of divergence in the force field of a highly trained athlete are considerably longer than those of a novice athlete. Furthermore, it can be inferred that a highly trained athlete relies more on external factors (such as gravity) than a less experienced athlete.

Keywords: *biomechanics of motor activity, jiu-jitsu, divergence.*

Introduction. In a number of studies of recent years, when describing the technique of performing exercises, the authors tend to rely on objective parameters [1, 3, 4]. Therefore, the search for such objective parameters in the field of martial arts is becoming an important task, which has both theoretical and practical significance.

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It was then assumed that the center of gravity moves in the force field $\vec{F}$ The divergence of the field is calculated using the formula:

$$div\ \vec{F} = \left(\frac{dF_x}{dx} + \frac{dF_y}{dy} + \frac{dF_z}{dz}\right).$$

In the case of a plane, the formula for divergence leaves two terms:

$$div\ \vec{F} = \left(\frac{dF_x}{dx} + \frac{dF_y}{dy}\right).$$

Divergence is a scalar quantity that reflects the convergence or divergence of a field. In our case, the meaning of the divergence of a force field is $\vec{F}$ distribution of the force under the action of which the center of gravity moves for shuttle-like movement on the coordinate plane, or the density of the force field.

If $div\ F > 0$ the field point is the field source.

I f $div\ F < 0$ the field point is the field sink [2].

To calculate the value $\vec{F}$ for the transition between two adjacent cyclograms, the value of the projections of the resulting force was calculated, under the action of which the center of gravity moves on the coordinate axis:

$F_{xi} = ma_{xi}$

$F_{yi} ma_{yi}$

where F_{xi}, F_{yi} projections of the force acting on the center of gravity for *i* cyclograms, and a_{xi}, a_{yi} projections of accelerations with which the center of gravity moves for *i* cyclograms.

Meaning for $div\,\vec{F}_i$ the transition between two adjacent cyclograms it was calculated by the formula:

$$div\,F_i = \left(\frac{F_{xi} - F_{x(i-1)}}{x_i - x_{i-1}} + \frac{F_{yi} - F_{y(i-1)}}{y_i - y_{i-1}}\right),$$

During the study, the intervals of change in the divergence of the force field for a highly qualified athlete and an athlete at the initial stage of training, the number of sources and sinks of the force field were assessed.

Results of the study and discussion. Figure 1 shows the changes in the divergence values of the force field in which the center of gravity of a highly qualified athlete and a novice athlete moves for one forward movement.

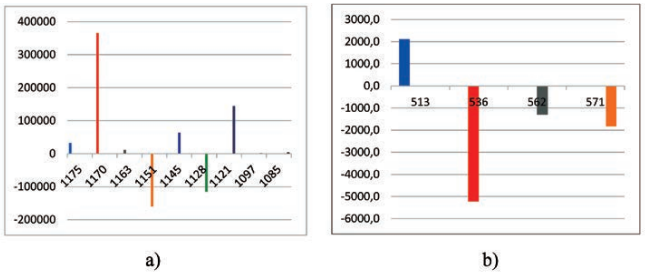


Figure 1. Divergence of the force field in which the athlete's center of gravity moves when moving forward in the shuttle manner a) athlete qualified as a master of sports in jiu-jitsu b) athlete at the initial stage of training

In a highly skilled athlete, the source of the force field can be seen at the beginning of the movement. Then comes the sink. In the middle of the movement, the source of the field is visible again. Then comes the sink. At the end of the movement, the source is visible. In an athlete at the initial stage of training, the source of the force field is visible at the beginning of the movement. Then comes the sink. Then the divergence value approaches zero. The end of the movement ends with the sink. The source of the force field at the end of the movement in a more experienced athlete is associated with the fact that he uses the force of gravity for his movement, and a less experienced athlete, on the contrary, tries to slow down the movement at the landing stage. Therefore, we do not see the source of the force field in a beginner athlete. The source of the force field in the middle of the movement in a highly skilled athlete is not very clearly expressed and, due to the large error of the research method, we cannot speak about it with confidence.

Table 1 shows the limits of change in the values of the divergence of the force field during forward movement and the lengths of the intervals of the divergence values $div\,\vec{F}_i$ for both athletes.

The data presented in Table 1 show that the lower value for a highly qualified athlete it is 30,6 times less than for a beginner athlete. The upper value for a beginner athlete it is 173,0 times less. The overall length of the interval is 71,7 times greater for a highly skilled athlete. This suggests that an experienced athlete is able to create a much greater density of his efforts compared to a less experienced athlete. At the same time, his mass is less than twice as large as that of a beginner athlete. Therefore, we can confidently say that the difference in divergence values is determined not by the difference in body mass, but by the specifics of the movement.

Figure 2 shows the divergence indices of the force field in which the center of gravity moves during the backward movement for both athletes.

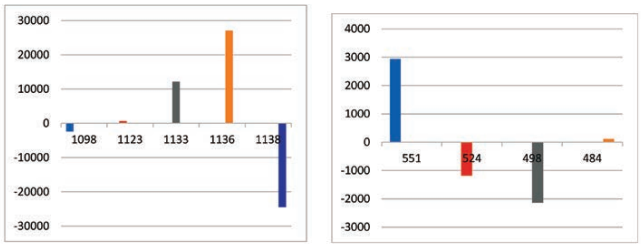
Figure 2 shows that a highly skilled athlete has a drain at the beginning of the movement. However, its value is small and it is impossible to talk about its

Table 1. Value change intervals $div\,\vec{F}_i$ in the process of moving forward

Athletes	Lower limit $div\,\vec{F}_1$	Upper limit $div\,\vec{F}_1$	Interval length $div\,\vec{F}_1$
Highly qualified	-159791,7	365625,0	525416,7
Initial stage of training	-5218,0	2113,1	7331,1

Table 2. Value change intervals $div\,\vec{F}_i$ in the process of moving backwards

Athletes	Lower limit $div\,\vec{F}_1$	Upper limit $div\,\vec{F}_1$	Interval length $div\,\vec{F}_1$
Highly qualified	-8313,95	36761,1236	45075,32
Initial stage of training	-2137,5	2941,071	5078,571



a) b)

Figure 2. Divergence of the force field in which the athlete's center of gravity moves when moving in the shuttle backwards manner a) athlete with the qualification of master of sports in jiu-jitsu b) athlete at the initial stage of training

actual existence due to the error of the method used. Then the source of the field is visible. Then the divergence value remains at the same level, and then the divergence value increases. At the end of the movement, a drain can be seen. For a beginner athlete, the source of the force field is visible at the beginning of the movement. Then two drains can be noted and at the end of the movement, a small source can be assumed.

The origin of the force field at the end of a highly qualified athlete can be explained by the fact that he uses the force of gravity to perform the end of the movement, while a beginner athlete, on the contrary, feeling the acceleration caused by the force of gravity, begins to slow down.

Table 2 shows the largest and smallest values to move backwards.

The data in Table 2 indicate that the minimum value $div\,\vec{F}_i$ y of a highly skilled athlete is 3,9 times less than that of a less experienced athlete. The highest value of a more experienced athlete is 12,5 times greater. The length of the interval in which the value changes $div\,\vec{F}_i$ for a highly qualified athlete it is 8.9 times greater.

It is obvious that the force field in the problem under consideration will be variable, because the center of gravity will move in two opposite directions: forward and backward.

Based on the results of the study, the following conclusions can be made:

- in the case under study, the density of the applied forces is significantly greater for a highly qualified athlete than for an athlete at the initial training stage;
- the range of values of the divergence of the force field is significantly higher for a highly qualified athlete compared to a beginner athlete.

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