THE PHENOMENON OF THE GOLDEN RATIO AS A NECESSARY CONDITION FOR THE EFFECTIVENESS OF THE "DOUBLE STEP RUNNING" SYSTEM

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Abstract

The article substantiates the hypothesis that the unity of the object-system "Double step running" is due to the "golden" proportional relations of the object-system to its subsystems and between the subsystems themselves.

1 Introduction

The modern understanding of motor actions is based on a system-structural approach that allows us to consider the body as a moving system. The system-structural approach to the study of movements is implemented in N.A. Bernstein's theory of the structurality of movements. The scientist claims that "Movement is not a chain of details, but a structure that differentiates into details" [1, 2, 3]. His own research allows us to scientifically reasonably assume the presence of patterns in the human locomotion system [4, 5, 6, 7, 8]. Identifying patterns of the human locomotion system is a significant biomechanics problem.

2 The main part

The object of this study was running locomotion. The subject of the study was the temporal structure of the running movement system. The structural elements in the system are not located by themselves, but are connected to each other. Communication refers to any kind of relationship between the parts of the system. The maximum number of heterogeneous connections (characterized by different mathematical relationships between the elements) in a system is determined by the number of possible combinations between the elements. In this case, only one relationship (relation) is allowed between the two elements. The formation of more than one (in this case, two) structural connections between two structural elements is possible only if the system is built on the basis of the so–called "golden" ratio or the principle of the "golden" ratio (Figure 1). In this case, for example, for two subsystems (or system elements), not one, but two homogeneous (with the same ratio) structural relationships arise. A similar number of homogeneous connections among the many subsystems in a system can characterize its unity: the more homogeneous the connections between the parts of the system, the more unified the system as a whole appears.

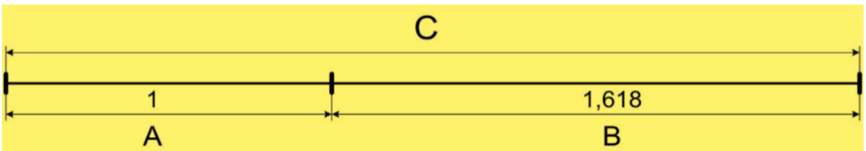

Figure 1 – Division of the segment according to the "golden" ratio, where B/A=C/B

An increase in the number of subsystems in such a system leads to a relatively large increase in its homogeneous structural relationships in accordance with formula 1:

$$A=n\times2-2 \qquad (1)$$

where: A is the number of homogeneous bonds; n is the number of elements of different dimensions at n1.

The unity of the "Double step running" object-system is probably due to the "golden" proportional relations of the object-system to its subsystems and between the subsystems themselves on the basis of homogeneous relationships. For example, the ratio of the "golden" proportion between the fixation of the forearm and its movement, between the movement of the shin and its fixation (Figure 2, 3). Thus, the unity of the temporal structure of individual movements of running locomotion can be conditioned by the condition – the largest (of the possible options) number of "golden" proportional relationships (homogeneous relationships) between subsystems, and hence the largest number of structural relationships (mathematical relationships) between them. Any other coefficient shows a smaller number of structural connections in the system under consideration (a homogeneous connection in the system is represented by the "golden" proportion – the ratio of 1.61803 ...).

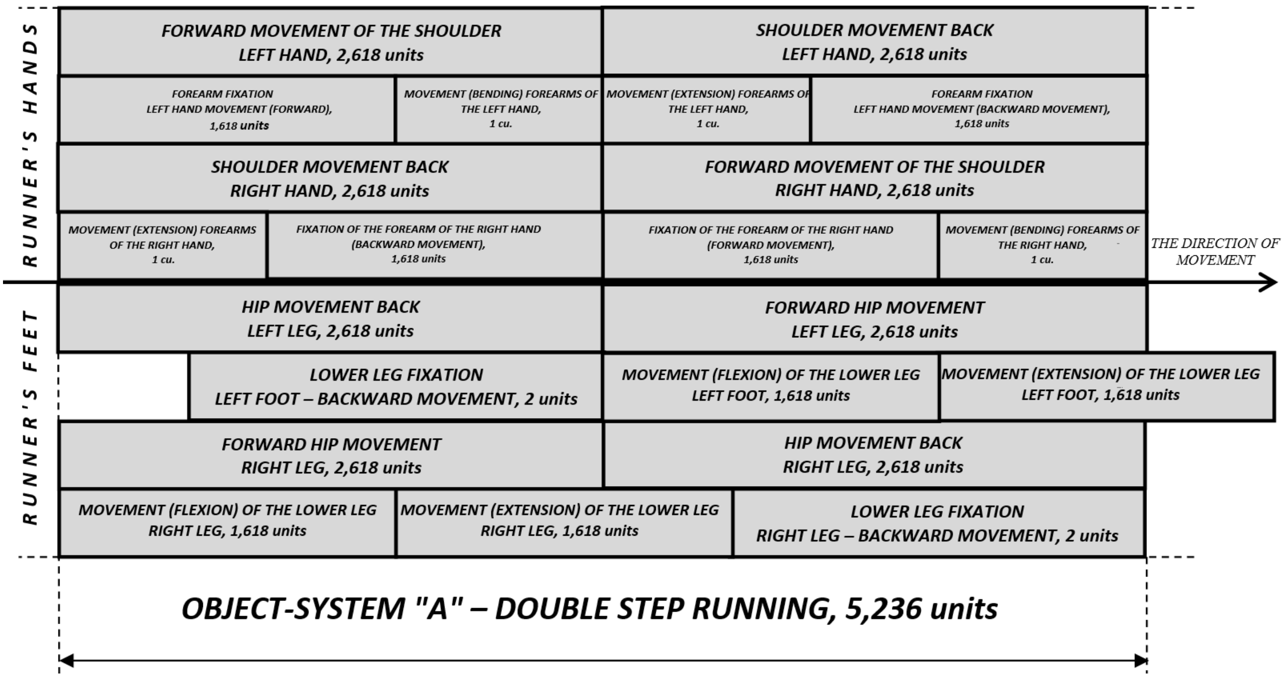

Figure 3 is a sub–graph of the temporal structure of double-step movements in running [5], where "Φ" ((√5+1)/2=1,618) and "ϕ" ((√5+1)/2)-1=0,618) – constants of the "golden" proportion

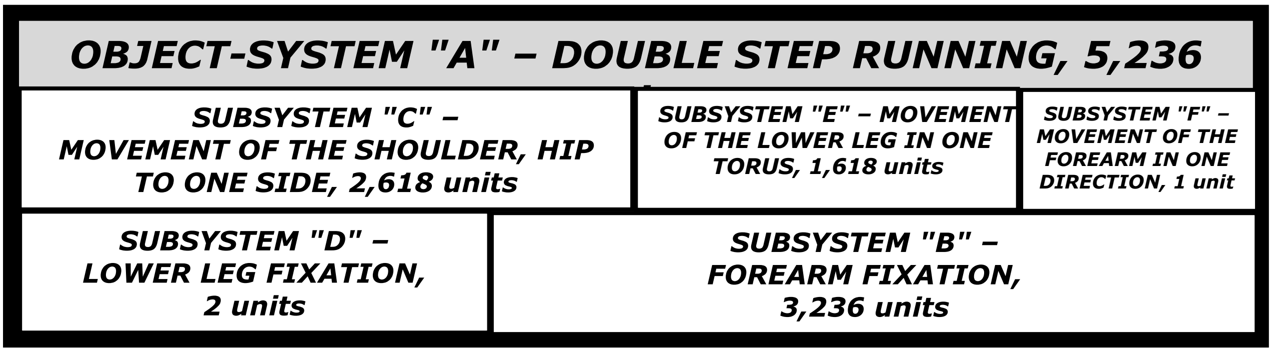

Figure 4 is a block diagram of the duration of athletes' movements in the "double step" cycle of running as the relationship of the object-system "A" to the objects-subsystems "B", "C", "D", "E", "F" [5], where the components of an object-system with a size of 5,236 conventional units (cu) are subsystems with sizes 1; 1,618; 2; 2,618; 3,236 cu.

The material system associated with the dimension of the "golden" proportion can be represented as an ideal one – in the form of a series of numbers reflecting its parameter. Thus, it is possible to imagine a running step system in a cycle of "Double step" running (Figure 4). In this idealized system, two large mathematical subsystems can be distinguished – one with the dimension of its parts in 1; 1,618; 2,618 and the other with the dimension of its parts in 2; 3,236. These 2 mathematical subsystems are coordinated with each other according to the same rule as the individual material movements of the runner's arms and legs that we are considering (see Figures 2, 3).

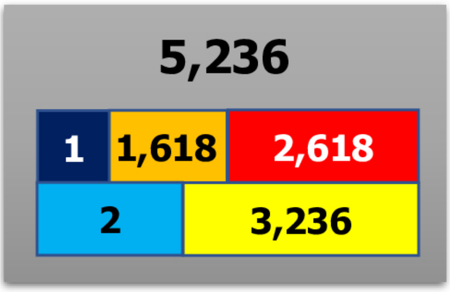

Figure 4 is a visual representation of finding 8 homogeneous "golden" connections (relationships) in a system of 5 segments of different lengths, commensurate with the duration of athletes' movements in the "Double step" cycle of running, where:
1) 1 ∝ 1,618…; 2) 1,618… ∝ 2,618…; 3) 1,618… ∝ 1+1,618…; 4) 2 ∝ 3,236…;
5) 2,618… ∝ 1,618+2,618…; 6) 2,618… ∝ 1+3,236 …;
7) 3,236… ∝ 2+3,236…; 8) 3,236… ∝ 1+1,618…+2,618…

Another example of an idealized system is a model of the optimal temporal (material) structure of the periods of support and flight of running steps in running, where the "golden" ratios act as markers of its optimum (Figure 5). The change in the duration of depreciation occurs due to a change in the speed of movement of the runner according to the geometric model of Figure 5: with an increase in it, the conditional depreciation ratio decreases and, conversely, with its decrease, the conditional depreciation ratio increases.

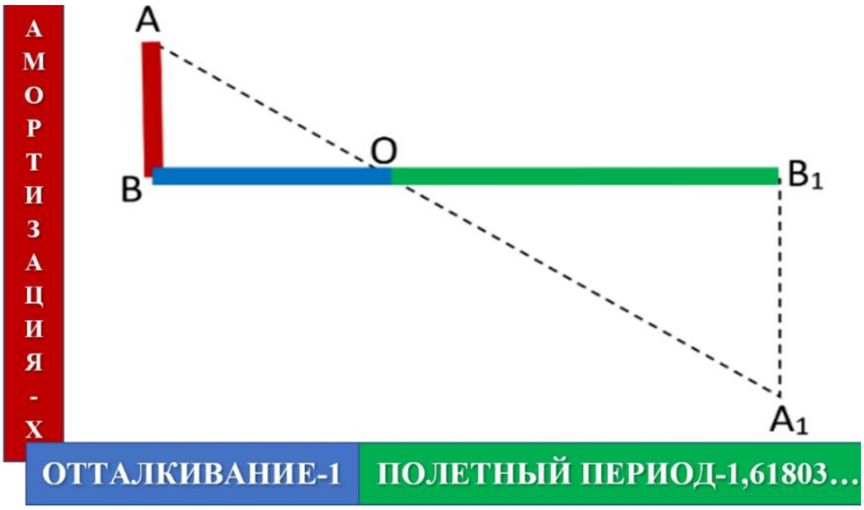

Figure 5 is a geometric model of the optimal time structure of the periods of support and flight of running steps in running, where: AB+ VO is a commensurate display of the duration of the reference period in running (VO/AV = 1.618...); AB is the duration of depreciation; BO is the duration of repulsion; OB_1 is the duration of the unsupported period in running; AO/OA_1 = 0.618... – lines connecting segments; B_1–A_1 is a conventional line perpendicular to B–B_1

One can imagine the material system "duration of periods of support and flight of a step in running" as ideal – in the form of a series of numbers reflecting its parameter (Figure 6).

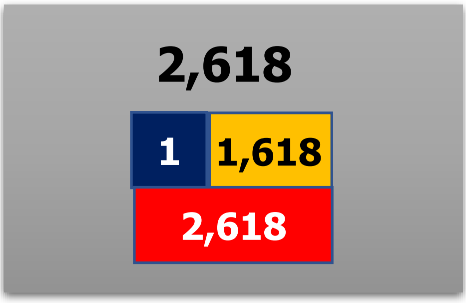

Figure 6 is a visual representation of finding 4 homogeneous "golden" connections (relationships) in a system of 3 segments of different lengths, commensurate with the duration of athletes' movements during periods of support and flight of running steps, where: 1) 1 ∝ 1,618…; 2) 1,618… ∝ 2,618…; 3) 1,618… ∝ 1+1,618…; 4) 2,618… ∝ 1,618+2,618…

An increase in the number of subsystems in the system leads to an increase in its homogeneous "golden" structural bonds in accordance with formula 1 (see formula 1) starting from 2, 3, 4, 5, 6 ... the elements that make up the system (Figures 7, 8, 9, 10, 11).

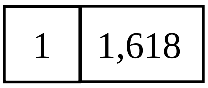

Figure 7 – Two homogeneous "golden" connections (relationships) in a system of 2 segments of different lengths, where the relationships correspond to it:

1) 1 ∝ 1,618…;
2) 1,618… ∝ 1+1,618…

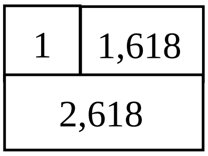

Figure 8 – Four homogeneous "golden" connections (relationships) in a system of 3 segments of different lengths, where the relationships correspond to it:

1) 1 ∝ 1,618…;
2) 1,618… ∝ 2,618…;
3) 1,618… ∝ 1+1,618…;
4) 2,618… ∝ 1,618+2,618…

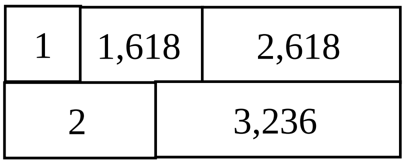

Figure 9 – Eight homogeneous "golden" connections (relationships) in a system of 5 segments of different lengths, where the relationships correspond to it:

1) 1 ∝ 1,618…;
2) 1,618… ∝ 2,618…;
3) 1,618… ∝ 1+1,618…;
4) 2 ∝ 3,236…;
5) 2,618… ∝ 1,618+2,618…;
6) 2,618… ∝ 1+3,236 …;
7) 3,236… ∝ 2+3,236…;
8) 3,236… ∝ 1+1,618…+2,618…

<table>
<tr><td>1</td><td>1,618</td><td>2,618</td><td>4,236</td></tr>
<tr><td colspan="2">3,618</td><td colspan="2">5,854</td></tr>
</table>

Figure 10 – Ten homogeneous "golden" connections (relationships) in a system of 6 segments of different lengths, where the relationships correspond to it:

1) 1 ∝ 1,618…;
2) 1,618… ∝ 2,618…;
3) 1,618… ∝ 1+1,618…;
4) 3,618 ∝ 5,854…;
5) 2,618… ∝ 1,618+2,618…;
6) 2,618… ∝ 4,236…;
7) 4,236… ∝ 1+5,854…;
8) 4,236… ∝ 2,618+4,236…;
9) 4,236… ∝ 1+1,618+4,236…;
10) 5,854 ∝ 1+1,618+2,618+4,236…

<table>
<tr><td>1</td><td>1,618</td><td>2,618</td><td>4,236</td><td>6,854</td></tr>
<tr><td colspan="3">6,236</td><td colspan="2">10</td></tr>
</table>

Figure 11 – Twelve homogeneous "golden" connections (relationships) in a system of 7 segments of different lengths, where the relationships correspond to it:

1) 1 ∝ 1,618…;
2) 1,618… ∝ 2,618…;
3) 1,618… ∝ 1+1,618…;
4) 4,236… ∝ 6,854…;
5) 6,236… ∝ 10;
6) 2,618… ∝ 1,618+2,618…;
7) 2,618… ∝ 4,236 …;
8) 6,854… ∝ 4,236+6,854…;
9) 6,854… ∝ 1,618+2,618+6,854…;
10) 4,236… ∝ 2,618+4,236…;
11) 4,236… ∝ 1+1,618+4,236…;
12) 10 ∝ 1+1,618+2,618+4,236+6,854...

3 Conclusion

1. The formation of more than one (in this case, two) structural connections between two structural elements is possible only if the system is built on the basis of the so–called "golden" ratio or the principle of the "golden" ratio.

2. The unity of the temporal structure of individual movements of running locomotion can be conditioned by the condition – the largest (of possible variants) number of "golden" proportional relationships (homogeneous relationships) between subsystems, and hence the largest number of structural relationships (mathematical relationships) between them.

3. The material system associated with the dimension of the "golden" proportion can be represented as an ideal one – in the form of a series of numbers reflecting its parameter. An increase in the number of subsystems in the system leads to an increase in its homogeneous "golden" structural connections in accordance with the above formula.

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