Coordinative overload approach in the high jump mark of a juvenile decathlete

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ABSTRACT

Coordinative overload approach (COA) aims to develop advantageous, fixed, and low-energy states in individual movement. A healthy and active decathlete was used, with three years of decathlon experience and 16 years old. The volunteer training decathlon in a social project and performs strength training at the High Yield Training Academy of the Estacio do Ceará University Center. The athlete does not train for the high jump event because of his social project limitations. The three stages of strength training were structural, intramuscular, and intermuscular, divided into 28 weeks. Results show an improvement of 25 centimeters about the initial mark after 28 weeks. The athlete had an improvement over his mark before starting the COA, even though he did not train the high jump.

INTRODUCTION

A principle of generating movement in organisms is what Gelfand and Latash (1998) they call it the principle of abundance: there are more ways to do any specific task than is strictly necessary. Bernstein (1967) intuitively reported that the emergence of an economic and harmonious movement requires the organism to reduce its degrees of freedom because, if this does not happen, the movement cannot be controlled in the face of the various perturbation arising from the organism, the task, and the environment (K. Newell, 1986), the concept to reduce degrees of freedom it was called "Bernstein problems".

Dynamic systems theory (DST) is a mathematical theory that is applied to several phenomena. This theory suggests that movement patterns arise from the synergistic organization of the neuromuscular system based on morphological and biomechanical factors, the environment and the task. The complex interaction between these components of motor behavior and the process of self-organization will produce an individual response (Davids et al., 2003; K. M. Newell & Vaillancourt, 2001; Renshaw et al., 2010). In summary, the interaction of several factors, intrinsic and extrinsic, will lead to large or insignificant changes in movement through the temporary restriction of degrees of freedom.

The DST suggests a correlation between the initial condition of the system, or habit, and the presence of states that will attract it, these states were called "attractors" and their complementary antagonists were called "fluctuations" (Davids et al., 2003; Frank et al., 2008). Attractor is defined as a stable state, a part of the movement that does not change regardless of the environment and that has a low energy cost to be performed, its presence guarantees the stability of the system (Bosch & Cook, 2015). Fluctuation is defined as deviations from the desired movement, variations that allow the movement to react and adapt to the disturbances of the task, the organism, and the environment, they guarantee the flexibility of the system (Torrents & Balagué, 2006).

Coordinative overload approach (COA) has as main objective to develop advantageous,

fixed, and low energy cost states in the athletes' movement (Bosch & Cook, 2015; Brearley & Bishop, 2019). The coach must disturb the athlete's pre-existing attractors to guide the self-organization process to the desired attractor state, causing a change in the motor pattern of the system. In parallel, a certain level of variability must be included to make the movement adaptable to different situations and, thus, to ensure that the attractors remain fixed while the fluctuations will deal with disturbances (Schöllhorn et al., 2010). This model can be used for sports training on the track or field, however, the use of this methodology in strength training can amplify the transfer capacity for the target sport.

To guide the process of self-organization, it is necessary to understand that movement emerges from the interaction of several levels, from the organization of atoms to the scale of the entire movement and, therefore, need to be developed from micro levels to macro levels (Pol et al., 2019). To satisfy this criterion, the training has three stages: the initial stage focuses on developing the structure of the muscles and tendons (general preparatory exercises), the intramuscular stage have to focus train the muscles individually in their attractor state and the intermuscular stage has the objective of developing the intermuscular attractors (Bosch & Cook, 2015), five attractors at this level are described in the literature for jumping and running: lock position of the hip, swing leg traction, foot plant from above, positive running position and keeping the head still (Bosch & Cook, 2015).

The decathlon is a men's event that comprises ten athletics events, divided into two days: 100 and 400 meters, long jump, shot put, high jump are the events of the first day of competition; 110 meters hurdles, discus, pole vault, javelin, and 1500 meters are the tests of the second day (Kim & Vigil, 2016), each event guarantees a certain score to the athlete depending on his mark. However, developing the necessary skills in the ten tests is a limitation in social projects, give the high purchase price of certain equipment, such as standards, crossbars, and mats for the practice of high jump.

The present study aims to verify the evolution in high jump events through the coordinative overload approach. Due to equipment limitations in his social project, the athlete does not train for the high jump event. The hypothesis is that the COA will improve the high jump mark.

METHOD

Study design

The present study compared the before and after of a single individual, being characterized as a quasi-experimental design of the N-of-1 subtype (Andrews & Frances, 2015).

Participant characteristics

A healthy and active decathlete (age: 16 years, height: 172cm, weight: 63kg) in the annual national competitive calendar was used as a sample, with three years of experience in the decathlon. In 2019, he occupied the first position of the state ranking in high jump and decathlon (16 to 18 years). He was gold medalist of the state championship and silver medalist of the regional championship in the high jump event, in addition to silver medalist of the state championship in the decathlon event.

The volunteer training decathlon in a social project and performs strength training at the High Yield Training Academy of the Estacio do Ceará University Center. Typically, his training routine consists of six weekly athletics workouts and five weekly COA, totaling eleven weekly sessions. Due to equipment limitations in his social project, the athlete does not train for the high jump event.

Throughout the study period, the athletes do not have any illness or injury. An explanatory meeting was held on the study procedures. A document explaining all the procedures and the informed consent form of the study were given to the athlete and his tutor, the procedures were started only with a signature of the term.

Anthropometric measures

The morphological aspects were verified through the collection of anthropometric variables in the right side of the body, using the triplicate criterion to calculate the mean. All anthropometric procedures followed the guidelines and technical standards of the International Standards for Anthropometric Assessment. The evaluator had previous experience and accreditation (level 1) granted by the International Society for the Advancement of Kinanthropometry (ISAK). The method used to estimate body composition was the five-component method proposed by Ross and Kerr (1991).

Coordinative overload approach periodization

The study lasted 28 weeks and the training was divided into structural, intramuscular coordination, and intermuscular coordination (Table 1). Isometric exercises had between 3 to 4 sets, 3 to 6 repetitions with time between 15 to 30 seconds in duration and 60 minutes of rest between sets. The dynamic exercises had between 4 to 6 sets, 4 to 8 repetitions with 30 seconds of rest between sets.

Table 1. Distribution of training in the weeks of the study

	Structural	Intramuscular	Inclusion of reactivity	Intermuscular	Stochastic disturbances
Week 1 to 5	x				
Week 5-10		x			
Week 11 to 15		x	x	x	
Week 15 to 21		x	x	x	
Week 21-24			x	x	x
Week 25-28				x	x

Structural stage

In the structural stage, the emphasis was on gaining a cross-sectional area and increasing the size and number of the actin and myosin filaments (figure 1A). In this stage, specificity is of

little value because the goal is to gain muscle structure with high muscle activation exercises, it can also be called the general preparatory exercises.

Figure 1 - Examples of exercises used in structural and intramuscular stages, respectively: (A) Maximum knee isometric, and (B) Single Leg Roman Chair, hamstring isometric contraction exercise.

Intramuscular coordination phase

In the intramuscular coordination stage, the emphasis was on training the muscles in their specific function in running and jumping: the biarticular muscles were trained in an isometric (figure 1B) and reactive manner, while the monoarticular muscles concentric and explosive manner (figure 2) (Bosch & Cook, 2015).

Figure 2 – Intramuscular stage exercise: Jump Strike, explosive concentric work on the vast muscles. Strength is also representative for gastrocnemius and soleus, transferring strength and slowing ankle dorsiflexion, respectively.

Intermuscular coordination stage

In the intermuscular coordination stage (Bosch & Cook, 2015), the objective was to train cooperation between the muscles, in this stage, the intermuscular attractors of running and jumping started to be developed (figure 3) and the fluctuations were trained with the inclusion of stochastic disturbances in the movement.

Figure 3 - Example of exercise in intermuscular stage: Single-leg clean to step, focus on the development of the intermuscular attractor "Lock Position of the Hip".

To produce movement variation and disturbance in intermuscular stage, unstable contact surfaces (figure 4) and aquabag (figure 5) were used. All exercises followed the philosophy of differential learning and, therefore, the trainer did not use verbal command and did not teach an ideal pattern of movement, as in this methodology error is a key part of motor learning (Schöllhorn & Bauer, 1998). To guide the athlete to the objective of the exercise but allow variations and errors to occur, the external focus approach was used (Gokeler et al., 2015).

Figure 4 - Exercise with variation inclusion: varying the contact surface.

Figure 5 - Exercise with variation inclusion: stochastic disturbances in the movement using aquabag.

Training load assessment

The athlete's training load was monitored both in strength training and on the track and field by the method proposed by Foster et al. (2001), which multiplies the time of the training session and the subjective perception of the effort to estimate the internal load of the session in arbitrary units. To assess subjective readiness and neuromuscular recovery, the Readiness and My Jump 2 applications were used, respectively, on an iPhone XR (Apple Inc., Cupertino, California, United States). In My Jump 2, the method chosen was the deep jump, from a 45 cm box, to assess

the athlete's reactive strength index. The objective of both evaluations was to guide the daily volume and intensity.

The three assessments aimed to make it possible to modulate the daily load according to the specific need of the athlete, as well as to monitor their evolution. To guide the amount of load applied in the week, "the acute:chronic workload ratio" was used (Gabbett, 2016). This indicator is found by dividing the load of the week the athlete is in and the average of the previous three weeks, the risk of injury is reduced, and the beneficial adaptations are optimized if the indicator is between 0.8 and 1.2.

The changes in the high jump mark were verified by the online system of the Brazilian Athletics Confederation (CBAt), which registers all the marks reached by the athlete in official competitions. For data analysis, descriptive statistics were used.

RESULTS

The result of the anthropometric evaluation morphologically characterized the athlete in three different masses, being these: muscular, adipose, and skin (Table 2).

Table 2. Morphological characterization of the individual

Variable	Value
Weight (kg)	63,00
Height (cm)	172,0
Muscle mass (kg)	22,39
Fat mass (kg)	16,10
Skin mass (kg)	3,61

Regarding load control by the method of Foster et al. (2001), the data show an average load, in arbitrary units, high. However, the mean of the acute:chronic workload ratio shows that the athlete was in a safe zone. The monotony was very high, showing that the training load fluctuated little (Table 3).

Table 3. Description of the athlete's weekly load records during the training weeks.

Variable	Mean	Standard deviation
Arbitrary units	3776,50	1924,8
Monotony	4,20	4,75
Acute:chronic workload ratio	1,14	0,699

The athlete's marks were collected directly from the website of the Brazilian Athletics Confederation, where all the marks of the official championships are registered. The marks were separated according to the weeks passed until the new competition (table 4), the result is expressed in absolute and relative values compared to the previous mark. The results show an improvement of 25 centimeters (15.62%) about the initial mark after 28 weeks.

Table 4. Temporary alteration of the athlete's marks in official competitions.

Week	Mark (cm)	Absolute Change	Relative Change
Initial mark	1,60	-	-
8th week	1,70	0,10	6,25%
20th week	1,69	-0,01	-0,59%
23rd week	1,75	0,06	3,55%
26th week	1,82	0,07	4,00%
28th week	1,85	0,03	1,65%

DISCUSSION

Historically, specific strength training in sport is very limited to biomechanical, physiological analysis, and exhaustive repetitions of simple and non-existent movements in the real sporting context (Schöllhorn et al., 2010). Schöllhorn (2012) demonstrated the basis of differential learning, in this approach the human being is treated as an adaptive and dynamic

system, which is directly influenced by the environment and, because of this, the coach must take advantage of errors and variations in technique to improve sports ability of your athlete.

To demonstrate this, Schöllhorn et al. (2010) performed an intervention on 28 youth hurdling athletes who were divided into two groups: the traditional training group and the differential learning group. The traditional training group performed repetitive educational exercises, with a focus on ideal movement and verbal corrections by the trainer. The differential learning group performed exercises with constant variation, no repetition was performed equally, variations in joint angles, speed, rhythm, equipment, environments, and variations of classic errors were used and, in a complementary way, no correction was provided by the coaches. The study lasted six weeks and totaled 24 sessions, except for exercises, all training was the same. At the beginning of the study, in a 60-meter test with a barrier, the traditional group and differential learning exhibited time averages of 11.76 and 11.70 seconds, respectively. In the end, the traditional group decreased 0.33 seconds in their time and the differential learning group 0.64 seconds. Analogously in the present study, the best marks of the athlete began to appear from the insertion of the variation in training.

This result is in line with the DST and the concept of “repetition without repetition” (M.L. Latash & Turvey, 1996), and reveals the importance of error and variations in the training environment, given the chaotic and unpredictable demands in sport (Gokeler et al., 2018). However, DST referred to a movement that arises from the self-organization of several scales, so a progression to the use of stochastic perturbations in the complete movements is interesting. During the entire period of the present study, the athlete had no contact with a high jump event (except in competitions), making progress to the complete pattern more gradual and decreasing the interference of sports training in increasing the mark.

Variation must be performed in existing movement patterns within the sports technique, being these intra- or intermuscular, and the forces present in the environment must be represented. Torrents and Balagué (2006) they emphasize that the human body is a dynamic

system that presents its movement in space through not only the control of the central nervous system but through the self-organization of this body in its different scales of time and size, interacting with the environment and the task. Thus, a certain pattern of movement can only be improved if the universal principles that govern its existence in the environment are considered in the athlete's training, these principles are the attractors.

Taking the hamstring training as an example in the present study, for this muscle group, only isometric and reactive exercises were used. The reason for this decision was the growing evidence that hamstring contraction in the running and jumping at high intensity is isometric and not eccentric (B. Van Hooren & Bosch, 2017a, 2017b).

Considering the "muscle-slack", which represents a state without tension being exercised by the muscle-tendon unit on the bone, only the isometric contraction would be susceptible to reactivity in the tendon. The swing leg retraction (i.e. intermuscular attractor), defined as the knee extension observed during the swing phase of the run corresponds to a passive stretching of the tendon while the contractile unit partially maintains its length in isometry and, moments before contact with the ground, the tendon retracts elastically increasing the strength and decreasing the cost of movement (Bas Van Hooren & Bosch, 2016), this is a good example of dependence between attractors of different size scales. If an eccentric contraction were to occur, anatomically it would be unlikely that there would be an improvement in the storage of elastic energy.

Therefore, the intramuscular attractor of the hamstrings, as well as the biarticular muscles of the lower limbs in terrestrial locomotion, is an isometric contraction with elastic tendon retraction, and this need represented in the weight training program. A recent work by Macdonald et al. (2019) showed that the single-leg roman chair was superior to nordic hamstring curl in improving muscle endurance assessed by the single leg bridge test. The monoarticular muscles do not cross two joints and, because of that, are not able to transmit force through the tendon itself (Voronov, 2004). Because of this, its contribution to terrestrial locomotion is significantly

different from biarticular muscles, with concentric contraction at high speed being its attractor state.

On a larger scale, intermuscular attractors are patterns that arise from the cooperation of several muscles. The main objective of these patterns that coexist with fluctuations in movement is to make the system stable in the face of the various disturbances that the environment provides, temporarily restricting the degrees of freedom of the system, making it controllable (Bosch & Cook, 2015; Latash et al., 2007; Latash & Turvey, 1996). The locked position of the hip (i.e., hip lock position), for example, ensures that the pelvic movement is stable to allow greater application of force on the support leg and protection for the hip joint (Bosch & Cook, 2015).

In summary, an expressive and rapid gain in high jump mark was observed in the investigated decathlete, despite not having trained for this event due to the lack of equipment in his social project. COA seems to have achieved the objective of transferring the strength training gains to the competitive result. It is important to highlight that the present study was conducted with only one athlete of the regional level and therefore should be careful with the generalization of the data found.

CONCLUSION

The present study sought to verify the changes in the competitive marks of high jump in a juvenile decathlon athlete who, due to equipment limitations, does not train this event in his daily routine.

The athlete had an improvement about his mark before starting the COA even though he had not trained for the high jump event. COA can be a way of maintaining a good performance in this event in the absence of the equipment to practice it. This may have been achieved due to the great specificity and representativeness of COA about the task and the environment of the high jump.

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DECLARATION OF CONFLICTING INTEREST

The author declares that there is no conflict of interest.

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