



## RESEARCH ARTICLE

### PROPOSAL FOR SELECTING WEIGHTLIFTING EXERCISES ON THE BASIS OF A CYBERNETIC MODEL

F. Javier Flores<sup>1</sup> and Juan Carlos Redondo<sup>2</sup>

1. Service of Physical Education and Sports, University of Salamanca, SPAIN.
2. Department of Movement and Sport Sciences, University of León, León, SPAIN.

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#### Abstract

The application of cybernetics to sport is based on two fundamental premises: logical organization of training and adaptation of loads to the real needs of the athlete at any given time. Thus, the aim is to achieve efficient selection of weightlifting exercises by means of an algorithm based on technical efficiency indexes, making it possible to undertake appropriate adjustments in the selection of exercises in accordance with the performance of weightlifters in a number of the most important weightlifting exercises. The cybernetic model described may be a useful tool for establishing which exercises are most necessary for a given weightlifter.

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#### Introduction:-

In order to achieve optimum performance, coaches need to plan training programmes that are specific to each sport and are prescribed in appropriate amounts (Bompa, 1994). If training dosages are properly programmed and performed, the chances of success in sport are increased (Bompa, 1994). In that sense, the optimal interrelation between the volume (quantitative aspect of training) and intensity (qualitative aspect of training) applied to the appropriated selection of exercises, should result in the maximization of sporting performance (Bompa, 1994; González-Badillo, 1991; Jiménez-Reyes and González-Badillo, 2011). However, setting the correct amounts of training load has always stirred up controversy in each different sport, so that it is still uncertain which training load is the optimum for achieving the best performance (Jiménez-Reyes and González-Badillo, 2011).

On these lines, it is necessary to confront athletes systematically with fresh stimuli that provoke new specific reactions so as to enhance their performance (González-Badillo and Ribas 2002). These stimuli are defined by the training load, and according to Siff and Verkhoshansky (2003) "the training loads refers to the quantitative calculation of the training work performed". To achieve the best results, effective prescription and organization of training must depend on calculating and applying the load components with most impact, which conventionally are volume and intensity (Bompa, 1994; Siff and Verkhoshansky, 2003). However, according to González-Badillo (1991), apart from volume and intensity, the selection of exercises represents a third component of load which has the most influence over weightlifting success.

Planning models have been developed to handle the correct dosage of components of load, so that an appropriate organization of the training process is now the key to all highly competitive sports (Milanović, 2013). Over time, different planning models have been proposed for application to sports training processes, including cybernetic models (García-Manso et al., 1996). In weightlifting, like all other sports, different planning models are used and

**Corresponding Author:- F. Javier Flores**

Address:- Service of Physical Education and Sports, University of Salamanca, SPAIN.

applied by specialist coaches according to their objectives, their capacities and their way of understanding and applying the theory and methodology of training. It would appear, however, that among the different planning models available, cybernetic theory applied to training organization has never been used by weightlifting coaches. Nevertheless, it can be helpful and easy for coaches to use it as a way of establishing an effective selection of weightlifting exercises, when appropriate mechanisms are put into play.

Cybernetic theories were proposed by Wiener in 1948 as a scientific way of managing and regulating the interdependent processes occurring in complex systems (Milanović, 2013). It would seem that the first proposal to apply a cybernetic model in sport was put forward by García-Manso et al. (1996), who outlined an algorithm as a tool applying cybernetic principles, in other words a cybernetic planning model, to the case of a hundred-metre sprinter. These authors established the main characteristics of the direct use of this model to plan training. In this case, cybernetics applied to sport is based on two fundamental premises for understanding training: logical organization of training loads and adaptation of loads to the real needs of athletes at any given moment. In this way, the establishment of a fixed-term training cycle decreases in rigidity and increases in variability, rendering it able to adapt to the genuine, specific needs of an athlete at each point in the training process. The method involves the presentation in a simple schematic way of the steps to be taken in solving a problem. It is able to adapt to situations through frequent checking of the process, allowing corrections to it where necessary (García-Manso et al., 1996). Nevertheless, it would appear that cybernetic models have not been used in practice in weightlifting circles. In all probability, the necessity of setting up practical tools to apply them has limited use of these models in planning training in this sport. However, given the right tools, such as appropriate algorithms for working with this type of methodology, an instance being the algorithm proposed by García-Manso et al. (1996), application of the cybernetic model to planning the selection of exercises in weightlifting might well be a good alternative that would render the selection of exercises precise and appropriate to the individual needs of each lifter. Hence, the purpose of the present paper is to provide a simple tool through which a more suitable choice of weightlifting exercises can be made, so as to establish a more efficient distribution of the repetitions required for each exercise. This allows the needs presented by each type of weightlifter at any given moment to be more effectively addressed.

#### **Weightlifting exercises:**

Any attempt to classify a given range of exercises is likely to proceed by ordering their elements using shared criteria (Jiménez-Reyes and González-Badillo, 2011). On these lines, according to González-Badillo (1991), the sorts of exercise used in weightlifting can be divided into three groups:

1. General strength exercises. These exercises should be seen as a complement to training, examples being bench presses, military presses or biceps curls, and performance is not dependent upon them.
2. Special strength exercises. These exercises mainly involve squats and pulls. These are exercises designed to develop the strength of large muscle groups such as the knee or hip extensors. These are not specific exercises, but they act on muscle-joint areas that are decisive for performance.
3. Specific strength exercises. Finally, specific strength exercises involve competitive lifts, like snatch or clean & jerk, exercises involving parts of competitive lifts, such as jerk or clean performed separately, and exercises derived from competitive lifts, examples being power snatch or hang power clean. With these exercises, the joint development of strength and technique is sought.

From a practical point of view, specific strength exercises and special strength exercises are essential in training schedules for weightlifting, because success in this sport is dependent mainly on these two types of exercise (González-Badillo, 1991).

Most of the world's weightlifting training programmes are derived from models developed by the weightlifting federations of Bulgaria and the former Soviet Union (Garhammer and Takano, 2003). On these lines, whilst Bulgarian and Soviet philosophies show notable differences, and the number of exercises used in training varies depending on the type of system, both methodologies have used specific and special strength exercises as a basis for weightlifting training. On the one hand, the Bulgarian system is implemented with a limited battery of six exercises (snatch, clean & jerk, power snatch, power clean & jerk, front squat and back squat). On the other hand, the Soviet system uses a greater variety of specific and special strength exercises (Garhammer and Takano, 2003) some of these are listed in Table 1.

**Table 1:-** Some of the specific and special weightlifting exercises.

SPECIFIC EXERCISES	SPECIAL EXERCISES
Snatch	Snatch pull
Snatch from the high blocks	Snatch pull from the high blocks
Snatch from the low blocks	Snatch pull from the low blocks
Hang snatch over the knee	Hang snatch pull over the knee
Hang snatch below the knee	Hang snatch pull below the knee
Power snatch	Hyper snatch pull
Muscle snatch	First snatch pull
Hyper snatch	Clean pull
Clean and jerk	Clean pull from the high blocks
Clean from the high blocks and jerk	Clean pull from the low blocks
Clean from the low blocks and jerk	Hang clean pull over the knee
Hang clean over the knee and jerk	Hang clean pull below the knee
Hang clean below the knee and jerk	Hyper clean pull
Push press	First clean pull
Back push press	Back squat
Jerk	Front squat
Back jerk	Half back squat
Push jerk	Half front squat
Back push jerk	Over head squat

**Technical Effectiveness Indexes:**

Regardless of whether Soviet or Bulgarian approaches are used in scheduling weightlifting training, it is necessary to have tools that indicate whether the ratios between the different types of exercises programmed provide an adequate proportion. Fortunately, there is a set of objective criteria for qualitative rating of exercises which allows the determination of the relationship between the lifter's level of strength and the amount of this used during the execution of weightlifting movements (González-Badillo, 1991). These criteria are called technical effectiveness indexes (González-Badillo, 1991), and through the ratios between them it is possible to determine the level of technical efficiency of the lifter, and thereby develop the technical efficiency profile that the weightlifter presents according to the results obtained in the main weightlifting exercises (Figure 1).

In drawing up a technical efficiency profile for a weightlifter, the proposal is to base it on comparison of the best performance achieved in the following exercises: back squat, front squat, snatch, power snatch, clean & jerk, clean, jerk and power clean. Thus, taking back squat lift as a reference, the ideal technical efficiency indexes of this lift and of the other listed exercises can be compared (Table 2), the technical efficiency profile of the weightlifter then being worked out (Figure 1).

As seen in Table 2, the reference lift for establishing technical efficiency indexes is the back squat. Squat lifts are of extraordinary importance in preparing weightlifters and even athletes from other sports (Szabo, 2013). The reason for choosing the back squat as the reference lift for setting the optimum ratios between lifts is that the back squat represents the basic strength exercise for an athlete's lower body (Vélez, 1992). This exercise expresses weightlifters' strength values, which are the factor limiting their performances in all the other weightlifting exercises (González-Badillo, 1991). In addition, the back squat is included in workouts by the vast majority of weightlifting coaches. Hence, this lift is used here in making comparisons and setting optimum performance ratios between different lifts undertaken by weightlifting specialists. It determines a number of technical evaluation criteria known as technical effectiveness indexes (González-Badillo, 1991; González-Badillo, 1974; González-Badillo and Ribas 2002).

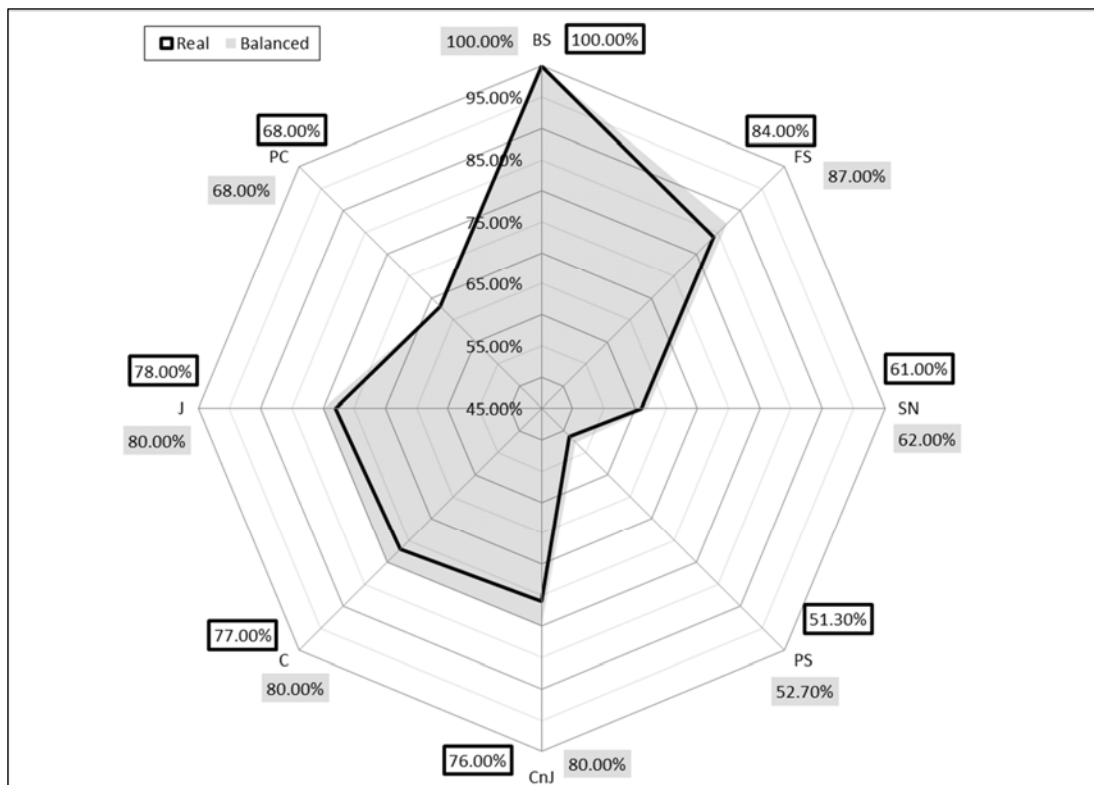
Some of the technical effectiveness indexes used in Table 2 were first proposed during the 1970s by the coach and weightlifting researcher A.W. Czerniak, these data being then incorporated in different pieces of work published later by various specialists in the world of weightlifting (González-Badillo, 1991; González-Badillo, 1974; Herrera, 1992). On these lines, González-Badillo (1991) catalogued the criteria of technical efficiency established by A.W. Czerniak and complemented his work by adding new indexes and discussing the topic extensively.

**Table 2:-** Technical Efficiency Indexes in Accordance with Optimum Ratios between Various Weightlifting Exercises and the Back Squat Lift. Based on Czerniak in González-Badillo (1991), Herrera (1992) and González-Badillo (1991; 1974).

REFERENCE LIFT	TECHNICAL EFFICIENCY INDEXES						
BS	FS	SN	PSN	CnJ	C	J	PC
100%	87% ± 3	62% ± 2	52,7% ± 2	80% ± 3	80% ± 3	80% ± 3	68% ± 3

Abbreviations Table 2: SN = Snatch, PSN = Power Snatch, CnJ = Clean & Jerk, C = Clean, PC = Power Clean, J = Jerk, BS = Back Squat, FS = Front Squat.

**Figure 1:-** Example of a Radar Plot of the Technical Efficiency Profile of a Weightlifter.



Abbreviations Figure 1: SN = Snatch, PSN = Power Snatch, CnJ = Clean & Jerk, C = Clean, PC = Power Clean, J = Jerk, BS = Back Squat, FS = Front Squat.

In Figure 1, the black line marks the real profile of a weightlifter on the basis of performance achieved in the back squat, front squat, snatch, power snatch, clean & jerk, clean, jerk, and power clean. The grey shaded area represents the ideal model of a balanced weightlifter in accordance with the optimum relationship between technical efficiency indexes. Thus, the shape of the radar plot will indicate the technical efficiency that lifters present in each of the exercises proposed with regard to their strength levels as established by performance in the back squat. Thus, when the black line falls outside the grey shaded zone, it means that lifters' technical levels are good, but they need to focus on improving their levels of strength. On the other hand, when the black line falls within the grey shaded area (as in the example shown in Figure 1), it means that the lifter concerned has a level of strength good enough to achieve a better performance in the exercises assessed, so that athletes in this case should focus on improving their technique.

On the other hand, a technical efficiency profile shows only the relationship between the strength and technical level of the weightlifter at a given point in time. Thus, in order to correct possible imbalances, it is necessary to lay down certain standards that allow determination of which exercises must predominate in training, according to the individual needs presented by the athlete. Hence, on the basis of a cybernetic sports planning model, a proposal will

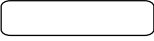

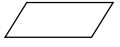


be made below for an algorithm enabling the selection of weightlifting exercises in accordance with the optimum technical effectiveness criteria for different potential choices.

#### **An Algorithm for the Selection of Weightlifting Exercises:**

In the light of the scenario presented, the proposal would be to undertake efficient selection of exercises for weightlifting by using an algorithm based on technical efficiency indexes. Such an algorithm is presented in Figure 2. This shows that by relating the various technical efficiency indexes mentioned in the literature (González-Badillo, 1991; González-Badillo, 1974; Herrera 1992, Roman, 1988) explained above, it is possible to establish the optimum choice of exercises for weightlifters to use according to their individual needs.

On the basis of this algorithm (Figure 2) it will be possible to make appropriate adjustments in the selection of exercises in accordance with weightlifters' performances in a number of the most crucial elements in training. Thus, by using knowledge of the technical efficiency profile of a given weightlifter, and by applying the algorithm described in Figure 2, it is feasible to make an effective selection of weightlifting exercises to compensate for any possible individual imbalance and thereafter to increase the performance of the lifter. To permit an understanding of the algorithm proposed, the descriptions and meanings of the symbols it uses are shown in Table 3.

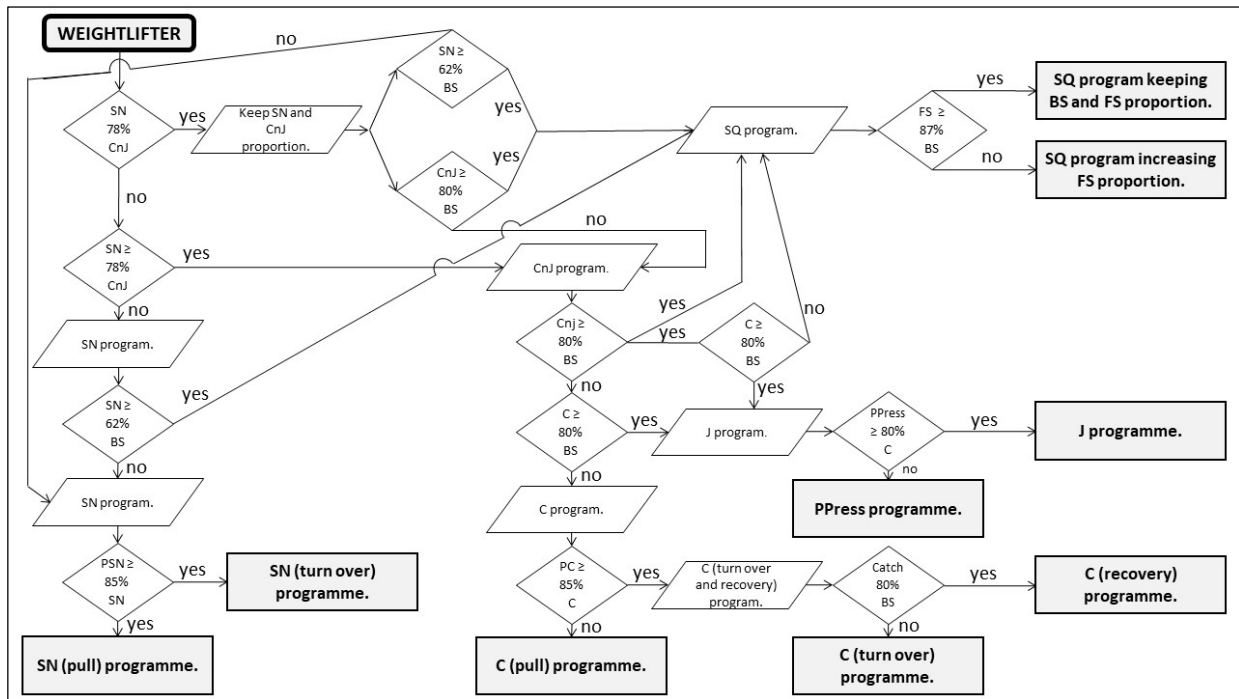
**Table 3:-** Descriptions and Meanings of the Symbols Used in the Algorithm for Selecting Weightlifting Exercises (Figure 2).

<b>Symbols</b>	<b>Meaning of the symbol</b>
	The terminal symbol marks the starting point of the system. In this case it contains the word "weightlifter" because the lifter is where the algorithm starts.
	The diamond symbol asks a question. The answer to the question determines which arrow is followed out of this decision shape.
	The parallelogram is used to show an input. In this case, the symbol shows the type of training programme to be developed by the lifter
	The rectangle is used to show the final conclusion of the process, the task, action, or operation to be carried out. It indicates an item that has to be carried out.
	The arrow connector shows the direction in which the process flows.

Given a knowledge and understanding of the symbols used in the algorithm proposed for choosing exercises for weightlifters (Table 3) data can be fed into it. These would essentially be derived from an awareness of the current performance of lifters in each of the weightlifting exercises listed previously: back squat, front squat, snatch, power snatch, clean & jerk, clean, jerk, and power clean. In this way, making a simple analysis, it is possible to know what kind of exercises the lifter should focus their attention to increase their performance.

The procedure for read the proposed algorithm is very simple. The starting point is always the terminal symbol located at the top left of Figure 2 and containing the word "weightlifter". From that point, readers merely continue in the direction marked by the arrow connectors in accordance with the answers to the questions asked in each of the diamond symbols, until the end of the route is reached. The information included in every diamond symbol is always a question. On the basis of the suggestions made by Czerniak in González-Badillo (1991), Herrera (1992) and González-Badillo (1991;1974), the value obtained is considered discrepant from the question only when it is greater than  $\pm 2\%$  for snatch exercises and  $\pm 3\%$  for clean & jerks, and squat exercises. The end of the route will always be a rectangular symbol indicating the type of exercises on which lifters must focus in order to increase their weightlifting performance. A number of the end-of-route symbols contain information within brackets, such as "C (pull) programme" or "SN (turn over) programme". This bracketed information indicates the kind of exercises to be prioritized by athletes in accordance with their specific needs and their profiles in terms of performance ratios detected between the exercises assessed. Hence, for example, if the end-of-route symbol indicates "C (pull) programme", it means that it is necessary to increase the proportion of exercises which involve improvement of the selection "pull" phase during the clean, because imbalances detected have their origin in this phase of the movement. In this example it would therefore be important to increase the proportion of an exercise such as the PC, in which performance exercises is determined by the efficacy of the pull stage.

**Figure 2:-** Proposed Algorithm for Selecting Weightlifting Exercises Based on Technical Effectiveness Index Ratios between Exercises.



Abbreviations Figure 2: SN = Snatch, PSN = Power Snatch, CnJ = Clean & Jerk, C = Clean, PC = Power Clean, J = Jerk, PPress = Push Press, SQ = Squat, BS = Back Squat, FS = Front Squat. The items included in all the diamond symbols are questions. The information shown in brackets inside rectangles indicates the stage of exercises that should be prioritized by the athlete.

Nevertheless, it must be kept in mind that the technical efficiency profile of a weightlifter is not stable over time. The situation will change, depending on the directions and strategies that are used and applied with the athlete involved. For this reason, it is necessary to undertake periodical re-evaluations using the algorithm proposed (Figure 2), so as to permit the current technical efficiency profile of the weightlifter to be re-established, and the optimum strategy to be determined. This will indicate what type of exercises should be prioritized to cover the needs of a given athlete at a specific point in time.

According to González-Badillo (1991), a macro-cycle is the basic training unit needed to achieve new levels of performance. In general, the length of a complete macro-cycle in weightlifting is between eight and fourteen weeks, this normally being enough to cause modifications in the performances of athletes (González-Badillo, 1991). In view of this, the algorithm proposed (Figure 2) should be reviewed at least once per macro-cycle so as to evaluate whether the selection of exercises being performed is the most efficient in covering weightlifters' needs.

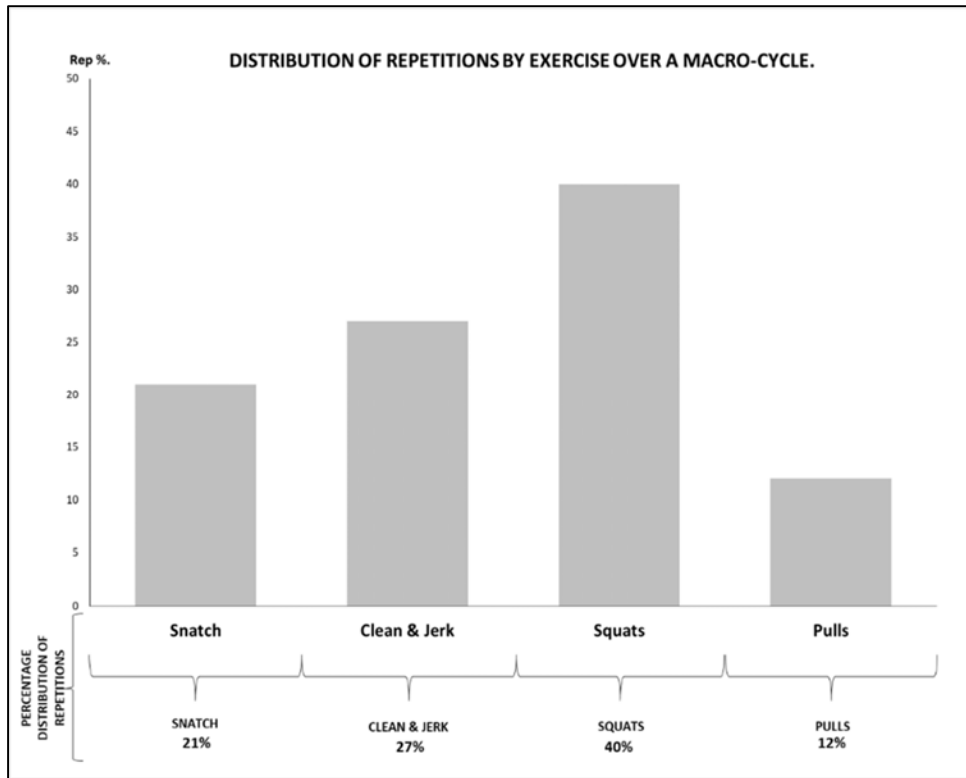
**Distribution of Repetitions by Exercise and Macro-Cycle:**

Once the technical efficiency profile of a weightlifter has been established and the algorithm proposed for selecting exercises has been implemented, the next step is to consider the distribution of the number of repetitions that the lifter should carry out for each type of exercise over the course of the macro-cycle. In all sports, load planning is programmed in accordance with various appropriate cycles or structures. According to Pendlay, cited by Haff (2004), a macro-cycle is a training period containing at least one preparatory, one competitive, and one transitional meso-cycle. It can be as short as two or three months, as in weightlifting, and is not usually longer than one year. The same concept of the structure of macro-cycles is adopted by González-Badillo (1991), who proposes the distribution of repetitions for each exercise over a whole macro-cycle that is shown in Figure 3.

As Figure 3 indicates, there is a long-standing model for the distribution of repetitions for each exercise group over a full macro-cycle. This is on the lines of 40% for squats, 10% to 12% for pulls, 20% to 22% for snatches and 26% to 28% for clean & jerk exercises (González-Badillo, 1991), although each performance of the clean & jerk is counted

as two repetitions (one for clean and one for jerk). Only repetitions at 80% or higher of 1RM are taken into account for specific strength exercises and squats, while only those at 90% or more of 1RM are tallied for pull exercises (González-Badillo, 1991).

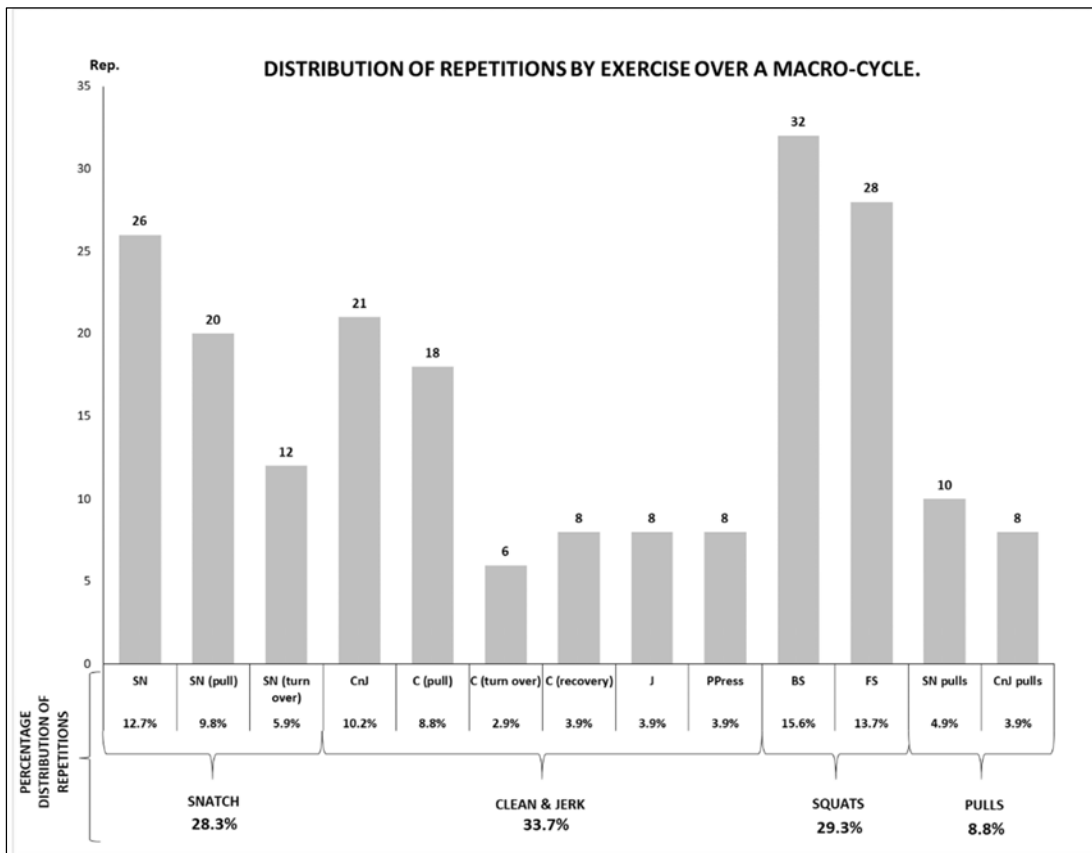
**Figure 3:-** Classic Distribution of Repetitions by Exercise over Macro-Cycle According to González Badillo (1991).



Nevertheless, in order to obtain more specific information about training, the proposal here is to organize the distribution of exercises in a more compartmentalized manner (Figure 4). This allows monitoring of the distribution of repetitions by type of exercise over the macro-cycle. It will be seen from Figure 4 that the number above each bar indicates the total of repetitions performed for a specific type of exercise. At the base of each bar there is an indication of the type of exercise together with the percentage that the total given represents within the overall number of repetitions undertaken in the whole macro-cycle.

Diverging from the classic division of weightlifting exercises established by Gonzalez-Badillo (1991), the present proposal establishes thirteen different types of exercises, so as to obtain more specific information about the distribution of repetitions performed during a macro-cycle, or any other given period of time, for each type of exercise. Thus, snatch exercises are divided into three similar blocks: classic snatches (SN); snatches focusing on the pull phase (SN (pull)), like power snatch or hang power snatch from below the knee; and snatch focusing on the turn-over phase (SN (turn over)), like hang snatch or snatch from high blocks. The same principle is dividing clean & jerk exercises into six blocks: classic clean & jerk (CnJ); clean focusing on the pull phase (C (pull)); cleans focusing on the turn-over phase (C (turn over)); clean focusing on the recovery phase (C (recovery)); jerks (J); and push press (PPress). Similarly, squat exercises are divided into two blocks: front squats (FS) and back squats (BS). Finally, pulls are divided into snatch pulls (SN pulls), and clean & jerk pulls (CnJ pulls). This division (Figure 4) permits a finer-grained, more specific awareness of the distribution of work performed than in the classic division proposed by González-Badillo (1991). In this, there is a division into only four groups: snatch, clean & jerk, pulls and squats exercises (Figure 3).

**Figure 4:-** Example of the Proposed Division of Weightlifting Exercises for Checking the Volume of Repetitions per Group of Exercises in a Macro-Cycle.



Abbreviations Figure 4:SN = Snatch, PSN = Power Snatch, CnJ = Clean & Jerk, C = Clean, PC = Power Clean, J = Jerk, PPress = Push Press, SQ = Squat, BS = Back Squat, FS = Front Squat

To conclude, knowledge of the technical efficiency profile of a given weightlifter (Figure 1) and use of the proposed algorithm for selecting weightlifting exercises (Figure 2) according to the individual characteristics of the athlete concerned allows modification of the volume and distribution of repetitions within each group of exercises so as to achieve a more rational and individualized distribution. Additionally, allocation of the number of repetitions in accordance with the division proposed in Figure 4 permits appropriate changes to be made in the programming of repetitions per exercise in a more precise way. This focuses attention on those exercises that best help to meet the needs of the athlete.

**Limitations:**

The proposal put forward here for the selection of weightlifting exercises on the basis of technical effectiveness indexes should be understood as having certain limitations that must be taken into consideration:

1. In order to develop the algorithm proposed in this work for choosing weightlifting exercises selection, it was assumed that the technical efficiency indexes proposed by various Soviet-bloc authors during the 1970s are valid. Although old, they are still accepted today by the community of practitioners and weightlifting coaches.
2. The technical effectiveness indexes from which the proposals for weightlifting exercise selection put forward in this study were developed are cited by prestigious authors and trainers in the world of weightlifting. However, access to the original sources of information is currently not possible (González-Badillo, 1991; González-Badillo, 1974).
3. The technical effectiveness indexes used were derived from a particular population, that of elite Soviet-bloc weightlifters. Hence, the proposals in this paper for choosing weightlifting exercises are mainly applicable to weightlifters with at least two to four years of experience. It is not suitable for novice weightlifters who are in the process of learning the techniques for exercises.



4. The technical effectiveness indexes employed have origins going back to a time such that the data on which they relied came only from men. Thus, the proposals made here are unlikely to suit women weightlifters.
5. The technical effectiveness indexes employed do not take into account the different categories of body weight. Thus, these ratios might vary in accordance with weight class.
6. Finally, the proposal made here refers only to the selection of weightlifting exercises. To achieve the best weightlifting performance, there is a need not merely for the correct choice of exercises, but also for the programming and application of a suitable dosage of volume and intensity for them (González-Badillo, 1991).

Future research should address the accuracy of the technical effectiveness indexes by discriminating between men and women, and between current weight classes. However, despite any up-dating or modification of the quantitative values for technical effectiveness indexes that may occur, the system proposed for the selection of weightlifting exercises by means of the algorithm set out in this work for the purpose would continue to be valid. All that would be required would be simple changes to the values in the corresponding diamond symbols.

### **Conclusions:-**

Numerous arguments are in frequent use by weightlifting coaches to justify their choice of exercises for lifters. Unfortunately, many of their criteria are derived from personal experiences and intuition, which makes it difficult to fine-tune selections adequately to the individual needs presented by a given athlete. It is true that an appropriate selection of weightlifting exercises can be made in various different fashions. Nevertheless, the proposals put forward in this paper offer a simple and objective way to help coaches make better-informed decisions when creating programmes for their athletes.

In the correction of possible imbalances and the development of a more efficient selection of weightlifting exercises during training, the algorithm proposed in this work offers the potential for an effective and easy-to-use tool able to focus training on those exercises that need to be enhanced. Hence, awareness of the suggestions provided by the algorithm, together with appropriate dosages of volume and intensity of training, would help to introduce substantial changes to improve effectiveness in the training of weightlifters.

The objective of this work is to provide a method for applying technical effectiveness indexes and for adapting these data so as to maximize weightlifting performance. This article highlights the importance of ensuring that a weightlifting specialist is sufficiently aware of the individual needs of a lifter, being thus able to make a more effective orientation of weightlifter's training.

To sum up, it is important to keep in mind that there is no single pathway to peak sports performance. There is not just one valid training system, because there are different coaches, different training ideas, different methodologies and different athletes (Szabo, 2013). Although training plans should be constructed on the basis of solid theory and methodology for training, practical work should be individualized in every case, taking into account the specific characteristics of each athlete (Bompa, 1994; González-Badillo, 1991; Siff and Verkhoshansky, 2003; Szabo, 2013). On these lines, the proposal put forward in this paper offers potential as a good tool for establishing which exercises are most needed by a given lifter on the basis of the performance achieved in the main weightlifting exercises.

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