Article

Updating of the Basic Criteria for Strength Training in Healthcare Field

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INTRODUCTION AND JUSTIFICATION

Whatever the meaning of sport to which we refer, when practicing it we will always be conducting some training, since as it has been indicated, sport is a physical activity and every physical activity demands a movement with certain intensity and performing time, these are elements that define the training itself1. In the field of exercise programs for health, training is also the procedure for activating the various organic systems that will lead to an improved quality of life and in some cases will lengthen it. However, in the field of leisure, a performance is also given since the very quality of life is determined and quantified, apart from the absence of disease, by the physical performance that facilitates the implementation of activities of daily life (ADL). Thus, any field of performance related to physical activity and sport can not be conceived without training[1].

According to the dictionary of the Royal Academy of Spanish Language, the term “update” means “bring up to today”. In the area of training, and more specifically with regards to strength training, this process of updating becomes much more evident and necessary. The training of this ability has been the victim of many unfortunate and inaccurate interpretations and they have resulted in not only a lack of consensus and heterogeneity regarding the basic criteria to be set for proper training , but also certain ignorance and little control over the type and characteristics of the stimuli provided when carrying it out[2].

This document was developed with the objective of establishing these basic criteria, updating the existing information and seeking greater consensus and uniformity of information regarding strength training for the professionals of the sciences of physical activity and sport, something very necessary if we want to provide more accuracy to our knowledge area[3-4].

Strength Training and Health

The deterioration of muscle function with age is undoubtedly one of the factors with the greatest impact on the loss of functional capacity. The muscle, speaking about structure and functionality, acquires today neuro-physiological dimensions that must be understood and properly sized for strength training to be truly effective in relation to its potential to improve health and funtionality[5,6,7,8]

At present the pathogenesis related to the loss of muscle mass that occurs with age (sarcopenia) is well documented. However, the ”dynapenic” process (strength loss related to age) acquires special visibility when related to functional impairment, taking into account that the decrease in muscle performance seems to happen a lot faster than the sarcopenic process itself[9,10].

The deterioration of maximal strength and the production of force in the unit of time (Rate of Force Development - RFD) with age will be closely linked, among other factors, with a sarcopenic process and/or selective loss, especially of the muscle fibers type II, and/or with changes in the qualitative characteristics of the muscle tissue (such as the increase of the fatty tissue and connective tissue). Therefore aging will be related not only with a reduction of the maximum force, but also with a decrease in the capacity of the neuromuscular system to produce force in the unit of time (RFD or explosive strength in the argot of the sports training)[11].

Thus, the conservation of muscle mass and especially of the maximum and explosive strength are priority objectives of the potential of the physical exercise in the pathogenesis, as well as in the treatment of disease, the functionality, health and quality of life[12].

Training Goals: Applied Force, Motion Performance and Functionality

- The different goals intended by training should consider a development based on the applied force concept[13].
- Applied force is the result of muscle action over external resistances. Therefore, applied force must be understood as the external manifestation of the internal strain generated in muscle in a given time13, being decisive both for performance and for health and functionality[14,15].
- In applied force, “modification” is a great validity criterion for assessing different factors related to performance and health. Applied force is measured by changes in the velocity of movement of external resistances, the body itself or by the distortion produced in different dynamometers, among others.

Conceptualization about Strength and its Training for the Improvement of Motion Performance

Maximal Force and its Training

- Maximal strength is the maximum value of force applied to any resistance (peak of force: newtons), therefore facing each resistance, a value of "maximum force applied” is obtained[13].
- In this way, any training which improves the applied force to any resistance or percentage of 1RM should be conceived as training for the improvement of “maximal force"[13].
- Therefore, the training of maximal force should not be associated exclusively with overcoming resistances next to values of the 1RM or the application of maximal force to an unsurpassed resistance (isometric maximal force)[13].
- The improvement of maximal force always implies exerting more force to the same resistance. This means achieving greater speed having the same load. If the resistances change, this implies applying more force at the same time or at the same speed (the load must be bigger than the preceding one moved in the same time), or the same force in less time or at a higher speed (the load should be smaller than the preceding one)[13].
- Likewise, the improvement of maximal force (displacement of the same resistance at a higher speed) will always suggest improving the production of power facing the same resistance[13].
- All these effects will be reflected in the displacement of the force-time curve (f-t C) toward the left and upward, the force-speed curve (f-s C) to the right and up, and of the power curve in the vertical and lateral directions[13,19].
- It is clear from the foregoing that speed can not be improved (reduction in the time used to overcome a resistance) without improving maximal force applied (implementation of more strength facing the same resistance)[13,19].
- When improving the applied force to the same percentage of the 1RM, the *deficit of force* is reduced, i.e. more speed is reached facing the same relative load[13,19].

RFD (Explosive Strength) and its Training

- "Explosive Strength", as known in the argot of training, should be understood as the production of strength in the unit of time (Rate of Force Development: RFD). It is therefore the production, development or rate of application of force in the unit of time (N·s-1) against any resistance, and so it is represented by the force-time curve[13,19].
- Maximal explosive strength or maximal RFD (maxRFD) is defined as the maximum production or development of force in the time unit in the entire production of force, or the best force-time relation of the entire force-time curve, and it is represented by the peak of the force-time curve[13,19].
- MaxRFD occurs before starting the movement in a concentric action. That is to say, in the static phase of any movement of a resistance higher than 30% of the maximum isometric force in the same starting position of the exercise in which maxRFD is measured[13].
- Improving RFD always suggests applying more strength in unit of time and therefore achieving greater speed facing the same resistance. Then, if the maximum force applied to any load improves, there will also be an improved RFD (force-time curve).
- Explosive strength (RFD) training should not be associated with the use of light resistances displaced at high speed. Any resistance can be worth to improve the RFD (explosive strength) if the voluntary production of force is maximal[13].
- The only condition to train (and probably improve) the RFD is to perform each action to the maximum speed

possible whatever the resistance used[13].

Power as a Result of Strength Training

- Mechanical power is the product of the magnitude of the applied force by the space (mechanical work) divided by the time taken to get it (Watts). This is equivalent to the product of force by speed and comes associated (is bound) to the force-speed curve[13].
- Given that any training which improves the maximum force applied to the same resistance will produce an improvement in the speed at which such resistance moves, only through the improvement of the maximum force applied to the same resistance can power be improved. In other words, it is impossible to train (improve) power without an improvement (training) of the maximum force. Therefore, the only condition to improve power is to improve the maximum force applied independently of the resistance used[13].
- From the previous, we can infer that the improvement of power is not a goal of training per se, but it is always a consequence of the improvement of the applied force[13].
- Improvement of power in training exercise does not always come along with a specific performance improvement.

Force Resistance and its Training (Resistance to the Loss of Strength)

- What has been traditionally understood as "resistance to force" should be understood as "resistance to the loss of strength", as it means to oppose to the loss of strength, not to the force itself. It should therefore be understood as the opposition/resistance to the loss of strength, which would be equivalent to the loss of speed16. It would therefore be the ability to maintain a peak of force and a production of strength in the unit of specific time during a given time[13].
- From this single point of view, the improvement of "resistance" will be produced if speed improves during the time taken for the competition or the distance travelled. If the "resistance to the loss of strength" improves, but the average speed is lower for the same time or the same distance, this improvement of the "resistance to the loss of strength" does not make any sense, since it is not a training effect that translates into a performance improvement[16].
- All trainings that achieve an improvement of the applied force facing the same resistance, will always improve the mean speed having the same load during a same number of repetitions[13].
- "Resistance to the loss of strength" training should be done and it is actually done, although we do not perceive so, when you train with the specific exercise of competition, which in turn is the *specific strength* training (useful force)[13,19].

Determining the Intensity of Strength Training

Percentage of the 1RM

- The intensity of strength training has been traditionally referred to as the value of a maximal repetition (1RM), estimated directly or indirectly by certain procedures, or with regard to a maximum number of repetitions per set (XRM)[19].
- This indicator remains a "gold-standard" in the current scientific literature, however the definition of the intensity of strength training can not be limited to the magnitude of the load used (% 1RM)[13].
- However, both RM and XRM have a number of disadvantages that would make them not advisable to use as a reference for training dosing, such as the uncertainty in the measurement, the change in the values with the course of the training and the excessive fatigue generated when measured to any person and especially to non-specialists and young people[13,19].
- The use of the same percentage of 1RM can originate different intensities and effects depending on the RM speed of the exercise, on whether the intentioned execution speed is the maximum possible, or that the maximum number of repetitions possible per set is done or not with that percentage.
- Dosing, evaluation and control of strength training must be done taking into account the speed of execution and speed changes facing the same loads/resistances pre-post training (not while being the 1RM between these loads)[13].

Execution Speed in Concentric Actions

- Speed is a determining factor or criterion to consider in the dosing, control and assessment of the strength training intensity[4,13,17,20,21].
- There is a very close relationship between the percentages of 1RM and the average propulsive speed with each percentage of RM in any exercise. The speed of execution with each percentage of the RM is specific to each exercise. In addition, the relationship between speed and the percentages of 1RM tends to be maintained or

modifies very slightly (in positive or in negative) with the improvement of the 1RM[23].

- Given that each percentage of 1RM has its own speed, the average propulsive speed reached facing an absolute resistance (mass) can be used as a good estimator of the relative load (% 1RM) which that resistance represents at each moment[23].
- Thus, the control of speed allows you to know quite precisely that we are training with the relative load or scheduled stimulus and so estimate/assess the performance improvement without the need of additional tests[20,23].
- It can be deduced from data collected in the above mentioned studies, that speed is a very reliable indicator of the intensity of strength training, and should be properly applied in any strength training instead of 1RM or a XRM.
- To program the load for strength training and performance evaluation it is necessary to consider only the "propulsive" phase of the speed of the concentric action[24].
- The higher the speed in a concentric action, the shorter duration and path represents the propulsive phase of the total concentric phase, and greater is the "braking phase" (higher deceleration than the deceleration of gravity when the object moves vertically and in ascending order). If the total phase of the movement is considered and not the propulsive phase, the stronger subjects will suffer in their measurements compared to the weakest ones when measured in performance to the same absolute load (mass). With percentages higher than 80% of the 1RM (although there can be some differences according to the exercise) the total length of the concentric phase is propulsive, that is, there is no braking and therefore the measurements should be correct considering any of the means[24].
- What is important about speed as an intensity factor is not that it is too high or too low in absolute terms, but that it is the maximum possible for the resistance given[13,23].
- With the same magnitude of relative load, executing its movement to the maximum concentric speed possible, offers higher maximal force gains, jump ability and sprint acceleration, than performing each action to half of that speed[13, 21, 22.]
- The loss of the average propulsive speed in the set (difference of speed between the fastest repetition, usually the first, and the last repetition of the set) is one variable that represents the degree of acute fatigue caused, and it can be a good indicator to adjust the scheduled load. In addition, this indicator is independent of the number of possible achievable repetitions in the set, at least with loads that allow performing approximately between 4 and 12 repetitions in the set[20].

Level of Effort (LE) and Speed Loss in the Set

- There is an approximately average number of maximal repetitions per set that can be performed with each percentage of 1RM according to the type of exercise and the subject training level[19,20].
- The LE as a load adjustment factor of strength training, according to the number of repetitions, will be determined by the relationship between the number of performed repetitions per set regarding the maximum possible achievable repetitions in that same exercise, with the same load and at that same time[19].
- In any context, the LE is a very advisable load adjustment factor in training and it must be analyzed and considered with respect to the impacts on the training effects[13,19,20.]
- There is a close relation between LE, speed loss in the set and metabolic stress (lactate and ammonium production)[20].
- In this way, at the same percentage of speed loss, the produced fatigue level results equivalent, regardless the number of repetitions that the subject can perform in that set, at least with loads that allow performing between 4 and 12 repetitions in the set[20].
- Likewise, there is also a close relation between height loss in the jump (CMJ) and lactate production, and between speed loss in the set and speed loss with the 1 m/s load[20].
- Strength training close to concentric muscle failure (maxLE) generates a great metabolic stress and high speed loss in the set that varies according to exercises. Both, great metabolic stress and speed loss in the set do not offer better results in the improvement of the 1RM than losing approximately a 20% of the set speed, and tend to decrease the effect with light loads and high speed exercises[25].
- Since the second half of the maximal possible repetitions that can be performed, the greatest speed loss in the set (and therefore the RFD) and a high concentration of metabolites (lactate and ammonium) are produced[20].
- Losses of speed lower than 30-35% of the first repetition speed offer greater strength gains than higher losses in the squat and bench press exercises[25].
- From the above mentioned studies, it would arise the practical application that the scheduled number of repetitions should be determined by the speed loss percentage; so that speed loss should be scheduled, and not the number of repetitions to perform[16].
- From these same studies it would arise the recommendation of not performing, in most of the cases, more than 45-50% of the maximal achievable repetitions per set at maximum speed, because this tends to offer greater strength gains rather than performing the maximal or almost maximal number of possible repetitions (maxLE).
- The foregoing suggests performing a lower volume of training and causing a minor fatigue level, allowing a faster

post-training recovery.

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