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Physical load control and prescription during resistance suspension strap training

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Abstract

The strap suspension training is a well-known and practiced resistance training methods. Despite its frequent use, there is lack of methods of control and prescription of the loads (e.g. intensity and volume) during exercising with this device and method. The aim of the present study was to propose a new practical approach in the control and prescription of physical load during resistance suspension strap training considering basic terminology. In suspension training with straps, setting the exercise using different subjection point height, rope length, distance from subjection point and attack angle could change both the intensity and the volume of the load. Considering the above, this information should be addressed by human science professionals, athletes and coaches in the designing and execution of conditioning and training programs using this method of suspension training, in order to make an optimal approach to a more individualized prescription. Likewise, the calculation and the use of attack angles and their variations together with the Suspension Training Total Resistance Load values give the possibility of making a more objective approach for the determination of an adequate training load, which based on the client's perception, could allow practitioners to generate a beneficial overload and obtain greater physical and physiological improvements.

Keywords: physical fitness, exercise test, endurance training, sport conditioning.

Introduction

Currently there are different methods of strength training, including multi-joint systems, the ability to modulate workloads, the development of strength, speed, power, balance, muscle hypertrophy and variability at training (Silva-Grigoletto et al., 2014).

These methods usually incorporate elements that fit under the term of functional training, and within these new methods of work under this modality are but are not limited to: Flywheel (de Hoyo et al., 2016; Onambélé et al., 2008), elastic bands (Gaedtke & Morat, 2016), muscular belt (Álvarez et al., 2005), sled training machine (Alcaraz et al., 2018), kettlebell swing (Jay et al., 2011), battle ropes (Fountaine & Schmidt, 2015), harness resistance training, among others with a rising popularity.

Among these innovative methods for strength training at functional level and using own weight for multiple tasks, suspension training with straps (Byrne et al., 2014; Calatayud et al., 2014), which is defined as those instruments that cause instability to lower and upper limbs using ropes or straps anchored to an attachment point (Calatayud et al., 2014). Different trademarks have been developed with subtle differences between them, among which are: TRX Suspension Trainer ™ (TRX®, San Francisco, CA, USA), Jungle Gym XT (LifelineUSA®, Madison, WI, USA), Flying (Sidea, Cesea, Italy), AirFit Trainer Pro (PurMotion™, Pelham, AL, USA). These instruments, due to their portability can be used for activation, warm-up and strength work during several consecutive days and in which the sports team move from one place to another to different locations and venues, these athletic processes of high load in a few days are increasingly common (Pino-Ortega et al., 2019; Rojas-Valverde et al., 2019). This devices have been developed looking after the maintenance of physical condition and preserving the high physical and physiological demands (perfectionism) related to sport in this type of competition and during the season (Salas-Ramírez & Rojas-Valverde, 2019).

Among recent evidence using this type of training, this instrument has been used for the purpose of athletic performance (Tinto et al., 2017), for therapeutic purposes for the care and improvement of patients with chronic diseases (Park & Hwangbo, 2014), in the rehabilitation of acute and chronic injuries (Fong et al., 2015), for the prevention of sports injuries (Ma et al., 2017), also, improvements in levels of body composition, muscle strength and respiratory capacity have been evidenced through suspension training programs with healthy people (Campa et al., 2018; Gaedtke & Morat, 2015; Smith et al., 2016).

The physical evaluations of people prior the execution of physical activity is fundamental (Rojas-Valverde et al., 2016) and will depend on the principles of training and functionality variables to be considered, as they are: the individuality of the person, considering each individual is different and with different objectives and needs, the frequency appropriate to maintain constant stimulus of the training, the volume or load of training per session (repetitions, series), the appropriate ratio of the density between the duration of the exercise and the recovery period (Silva-Grigoletto et al., 2014).

Different attempts have been made to develop methods of quatification, control and prescription of physical load during suspension training with straps in different populations (Gaedtke & Morat, 2015; Melrose & Dawes, 2016), but these attempts continue to leave a lack of information regarding the application of these methods in practice. The purpose of this study was to propose a new field practical approach in the control and prescription of physical load during training with resistance suspension straps.

Method

The training instrument consists of several essential parts for good use during physical activity, among which are: anchor system (loops, carabiner, straps, ropes), straps or ropes, adjustment tabs and buckles, handles and buckles foot cradles (figure 1).

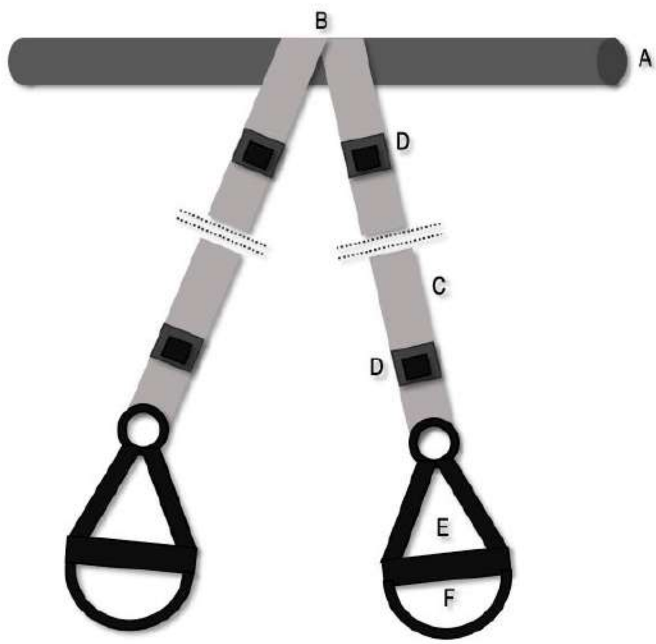

Figure 1. Suspension training basic device´s parts: A. Subjection structure, B. Anchor system, C. Straps, D. Adjustment tabs and buckles, E. Handles and F. Foot Cradles.

Basic concepts

The rope suspension training scenario has basic and essential concepts for the quantification of the physical load (figure 2). The following principles and conditions should be considered:

Subjection point height: the height should be consistent with the height of the executing person; a very high or very low clamping mean a decrease in the number of variants of attack angles and distance to the subjection point. It is recommended that the clamping height be 20-25% greater than the height of the user (e.g. 170cm user high= 204cm subjection point height).

Point of attachment or anchoring: it must be a solid structure, a point that is insured and resists the force exerted by the participant, this is essential for the safety of the executing person. It is recommended that beams or tubes are highly fixed to walls.

Strap length: the length of the ropes or straps will depend on the position of the body in terms of inclination (attack angle) and distance from the point of attachment, to modify the intensity at which the work is performed. The average commercial measure of the strings is from 182cm to 380cm.

Attack angle: this variable is defined as the inclination of the body with respect to the ground in which the exercise is executed, the angulation would be defined by the length of the rope, the type of exercise and the distance to the axis of support.

Support base: it must be a stable base to prevent falls, injuries, sprains or shocks while using the straps. It is recommended to use wedges fixed to the floor, rubber or non-slip materials for user safety.

Distance from subjection point: refers to the total distance from the clamping point of the floor to the support base of the executer. Likewise, the characteristics of the specific instruments used (e.g. string length) should be considered to define the distance from the point of attachment to the ground. Additionally, it is recommended to mark the distance for future use and programming of the exercise.

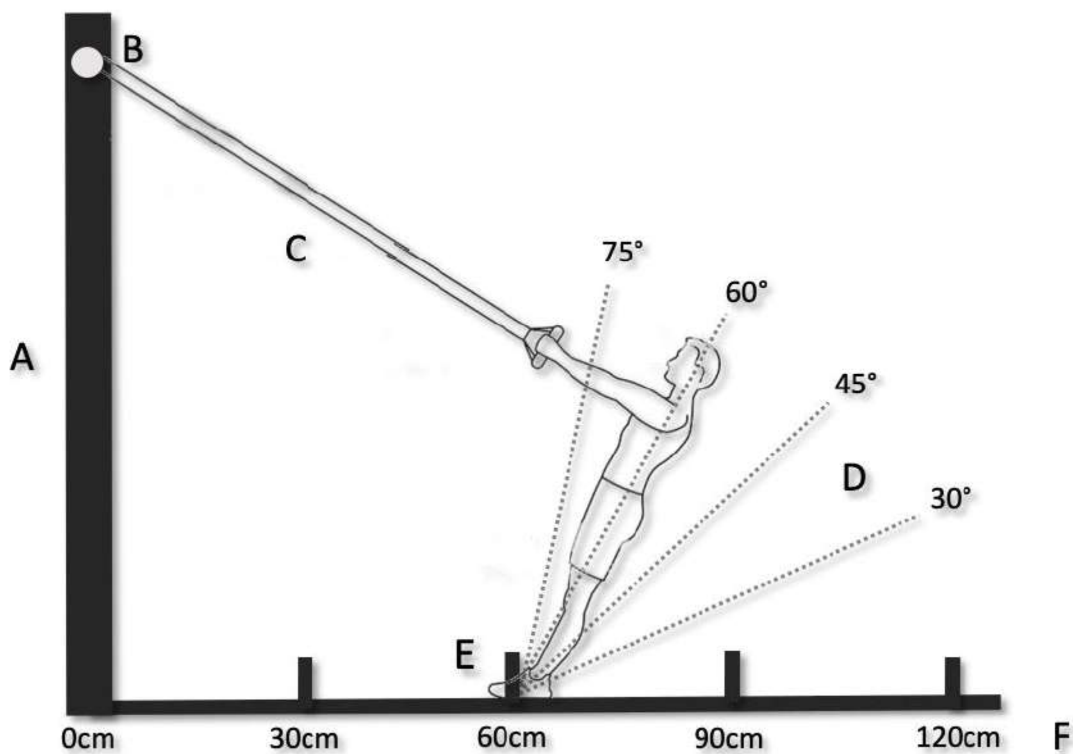

Figure 2. Schematic design of a basic suspension rope training scenario. A. Height of subjection point, B. Subjection point, C. Strap Length, D. Attack angle, E. Support Base, F. Distance from subjection point.

Evaluation

The evaluations of the upper and lower limbs are necessary for the optimal prescription of training with suspension straps. To ensure an adequate evaluation and that this triggers an optimal prescription of the loads when using this training tool, practitioners should consider the type of exercise to be performed: core training, isotonic exercises of open and closed chain, power, exercises of proprioception and instability, compound / mixed exercises, which would define the type of evaluation to be carried out.

Firstly, and considering that not all professionals and coaches have access to high-tech tools or gold standard measurement, it is recommended to perform a battery of general tests to know the physical capacity of the participants (Rojas-Valverde et al., 2016). These evaluations include:

- General clinical history and physical activity level: International Physical Activity Questionnaire (Wanner et al., 2016), weekly physical activity level (Castillo & Molina-García, 2009).
- Aerobic capacity (maximum heart rate) (Tanaka et al., 2001).
- Cooper's test (Bandyopadhyay, 2015).
- Working heart rates (Karvonen et al., 1957).
- Hamstring flexibility (Bandy & Irion, 1994).
- Body composition (weight, height, fat percentage) (Guerra et al., 2010; Siri, 1993; Vickery et al., 1988).
- Power in horizontal (Krishnan et al., 2017).
- Vertical jump (Sánchez-Ureña et al., 2018).
- Muscular resistance (plank) (Parkhouse & Ball, 2011).

These are basic test recommendations, but coaches should apply those specific testes to this evaluation protocol. During assessments the perceptual level of the training load should be monitored (Borg, 1982). Among the measurements according to the type of training, the following are proposed:

Core exercises in suspension: it is proposed to perform two types of evaluation according to the level of physical activity and physical capacity of the participants. For experienced participants, it is proposed to perform core tests, where the desired position is maintained until volitional fatigue (e.g. plank until correct initial position changed) (Parkhouse & Ball, 2011). On the other hand, for people with less physical capacity it is proposed to do series of 15-30 seconds of the core exercises and to count how many series with breaks of 90 seconds between series can be supported with good technique. In these two scenarios the evaluation must be consistent and specific with the objectives of each participant.

Power exercises: it is proposed to perform a measurement of the number of repetitions (eg jumps, squats with jump) possible for about 30-90 seconds, or equivalent to the needs of the participant. Example: Latissimus pull down in suspension straps (Morat et al., 2019), push-ups on suspension straps (McGill et al., 2014), among others.

Proprioception exercises: provide the recruitment or co-contraction of the muscles surrounding the joint to provide stability in the unstable base in which they are, for example: push-ups plus on sling suspension, sling suspension plank prone, sling suspension plank supine, bilateral limbs, limbal unilateral suspension sling, supine bilateral bridge limbs, unilateral supine bridge limb (Nasb & Li, 2016). These proprioceptive exercises can evolve tasks where vision is suppressed, this increases the difficulty of the task exponentially.

Isotonic exercises of open or closed chain: you can evaluate the number of repetitions in 30-90 seconds that you perform in a distance from subjection point (m), attack angle (°) and support base determined considering the type of training and desired demands. It is important to consider that this position must be quantified.

Load control and prescription

The load control dependent on the length of the rope, the body inclination, the distance between the anchor point and the handles, restricting of support points. Therefore, the greater the inclination of the body with respect to the anchor point, the greater the intensity of the exercise due to the increase in the body weight to be lifted.

It is recommended to make weekly or biweekly adjustments depending on the needs of the person and the difficulty required or the planning stage. It is not recommended to increase two variables from one week to the next at the same time. These increases are recommended to be between 5-15% of the total load. The total load recommended is calculated as follows:

$$\text{Suspension Training Total Resistance Load (STTRL)} = 2 \cdot \text{attack angle} + \text{distance from subjection point}$$

The lower the STTRL value, the greater the burden of this value should be: two-fold to three-fold the value if there is an instability or perception suppression and three-fold to four-fold the value if there is added multitasking tasks plus instability or perception suppression, this is going to depend from the consideration of the coach or professional regarding the level of instability and multitasking settings. It is proposed to monitor the angle using the following formula:

$$\cos\Theta = \frac{\text{cathetus(m)}}{\text{hypotenuse (m)}}$$

Where cosΘ is the cosenous of the attack angle, cathetus is the distance from subjection point and hypotenuse is the strap length.

For the prescription of training it is proposed to consider the difficulty that the increase of the total load means. For this, four levels are established for managing the increase or decrease of total workload, which are:

Level 1: increase or decrease in the length of the strap.

Level 2: increase or decrease in the attack angle of the body with respect to the anchor point.

Level 3: unilateral work generating greater instability or the use of unstable materials or bases.

Level 4: a greater increase in the complexity of the exercise to work (multi devices, multi tasking).

Modifications of the load should not be made in the previous order, but it is advisable to consider the objectives of the activity prior to jump from one level to another or skip one level in the sequence. It must be considered that to increase the load the following principles are met, STTRL will increase if:

1. The angle of attack is decreased (increase in length of device straps).
2. The distance to the attachment point is decreased.
3. Involves or increases instability (decreases stable support point).
4. Several tasks are involved at the same time (multitask settings).
5. Two or more previous conditions are combined.

During the exercise, the perceptual training load should be monitored at all times (e.g. Rate of Perceived Exertion, Borg Scale (Borg, 1982)). The attack angle and the distance must be permanently monitored to ensure adequate control of the load. Likewise, multiplanar exercise with ranges of varied movements are recommended, allowing 8 to 15 repetitions per exercise for a total of 2 to 3 series and a weekly frequency of 2 times per week (Convis, 2009; Rosania, 2016).

Control and prescription example

Table 1 shows an example of how to apply the recommendations and principle explained above in order to prescribe, control and modify load throughout days or weeks.

Table 1. Load control and prescription example during strap suspension training.

Week	Exercise	Attack Angle (º)	Distance From subjection point (cm)	Instability or perception suppression	Multitasking	STTRL calculation	STTRL*
1	Rowing	60	160	-	-	(60/2)+160	190
2	Rowing	45	160	-	-	(45/2)+160	182.5
3	Rowing	60	120	-	-	(60/2)+120	150
4	Rowing	60	180	↑	-	((60/2)+180)/2	105
5	Rowing	60	160	↑	-	((60/2)+160)/2	95
6	Rowing	45	160	↑	-	((45/2)+160)/2	91.25
7	Rowing	60	120	↑	-	((60/2)+120)/2	75
8	Rowing	45	160	↑↑	-	((45/2)+160)/3	60.83
9	Rowing	45	120	↑↑	-	((45/2)+120)/3	47.5
10	Rowing	45	120	↑↑	↑	((45/2)+120)/4	35.62

*Total STTRL was increased at high rate between weeks only for example purposes.

Discussion

An adequate prescription of training through devices that uses suspension, is essential for success in the design of effective training programs and therefore to have guides to direct this type of training. Although there is evidence of improvement in physical fitness variables through suspension training (Campa et al., 2018; Gaedtke & Morat, 2015; Smith et al., 2016); there are different studies that have shown how variations in attack angles can generate different stimuli in the same exercise. Gülmez (2016) found differences in the percentage of body weight mobilized during the exercise of push-ups in suspension to different angles, demonstrating the importance of considering this aspect when designing work conditioning programs. Aguilera-Castells et al. (2019) found that a greater distance between strides in suspension exercises with movement frequencies of around 70 beats per minute in dynamic exercises generate greater work muscle tension comparing them with shorter stride distances and isometric work.

Also within the efforts to achieve guidelines to orient the process of determination of workloads, Giancotti et al. (2019) in a study conducted in adults applying the exercise of rowing in suspension and where they used different attack angles determined that the increase of the strap length generated a decrease in the reaction force of the ground and the inclination of the body, thus giving equations that could help the prediction of the workload. Under a similar line, Francesco et al. (2017), evaluated in the push-up exercise seven different positions of the elbow during isometric contractions and thus allow the assessment of the load between the upper and lower extremities, observing that as the length of the device in suspension increases the inclination of the body decreases, the reaction force on the body also decreases and the tension on the device tends to increase, with the main conclusion being that the distribution of the load between the upper and lower extremities it seems to change both when the inclination of the body is modified and the length of the belts of the device in suspension.

Limitations

While there is growing evidence of attempts to determine equations or guides to direct and control training load when using suspension training devices, the wide variety of existing exercises that can be applied using this training means it is very complex in the first instance to find a load control method that can be applied equally without distinction of exercise. If we add the combination of training methods (e.g. methods for the stimulation of stability) the complexity of the applicability of existing proposals increases. Likewise, there is not yet enough evidence that assess the differences in physical load due to the modifications of attack angle, height of subjection point and distances from subjection point for a group of exercises that could lead to obtaining a robust work guide. The present study is an initial approach to the quatification of the load and it should be confirmed in the practice.

Practical applications

Any professional in human movement sciences or personal trainer who incorporates the use of suspension devices into their training programs, should consider certain aspects such as subjection height, attack angle, strap length and distance from subjection point. Before exercising, there should be an initial evaluation considering individuality of each client.

Another factor to be considered and that is essential in the design of this type of training programs will be the inclination of the body (attack angle) or the distance to subjection point at the time of performing the exercises, since if the objective is the increase in the intensity of work both should increase, which constitutes an important approach in the control of the workloads of each person. In addition, the calculation of the STTRL should be considered when possible and in which case values may be established within certain degrees to determine a possible proposal of difficulty levels applicable to different training possibilities that together with the proper length of the ropes and the distance to the subjection point are variables that should not be overlooked, not forgetting that they must work with different angles of attack both to give greater variability to training and to generate overloads in order to cause greater stimuli.

In addition to the above, the control of load carried out through the perception of each client is important and for this, the use of the rate of perception scale, is an applicable tool that allows monitoring and adjusting if necessary the variables related to this type of training mentioned previously.

Conclusions

In suspension training with ropes, setting the exercise using different subjection point height, rope length, distance from subjection point and attack angle could change both the intensity and the volume of the load. Considering the above, this information should be addressed by human science professionals, athletes and coaches in the designing and execution of conditioning and training programs using this method of suspension training, in order to make an optimal approach to a more individualized prescription Likewise, the calculation and the use of attack angles and their variations together with the STTRL values give the possibility of making a more objective approach for the determination of an adequate training load, which based on the client's perception, could allow practitioners to generate a beneficial overload and obtain greater physical and physiological improvements.

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