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Influence of the Strap Rewind Height During a Conical Pulley Exercise

by
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The use of flywheel devices has increased in popularity within resistance training programs. However, little is known about modifiable variables which may affect power output responses, as the rope length and the height level used in a conical pulley device. The aim of this study was to assess the influence of using three different rope lengths (1.5, 2.5 and 3.5 meters) and four different height levels (L1, L2, L3 and L4) on concentric peak power (PPconc), eccentric peak power (PPecc) and eccentric overload (eccentric/concentric PP ratio; EO) during conical pulley exercises (i.e. seated and stand-up row). A total of 29 recreationally trained subjects (25.3±7.1 years; 1.74±0.06 m; 72.5±8.3 kg) took part in the study. Testing sessions consisted of 1 set of 10 repetitions under each condition; experiment 1: seated row exercise using the three different rope lengths; experiment 2: stand-up row exercise using four different height levels of the conical pulley. Results from experiment 1 did not show differences between rope lengths, although a trend for greater PPecc (ES=0.36-0.38) and EO (ES=0.40-0.41) was found when using longer rope lengths (2.5 and 3.5). Experiment 2 showed significant increases in both PPconc and PPecc as the height level used was closer to the cone base (L4). In contrast, EO values were significantly greater when using upper height levels (L1). These results suggest that the height level used during conical pulley exercises highly influences power output responses. Therefore, this variable should be carefully managed depending on the training goal (e.g. power vs hypertrophy).

Key words: *eccentric overload, strength, power output, flywheel.*

Introduction

Resistance training is probably the most common strategy aiming to optimize muscular force and power adaptations. It is broadly accepted that adaptations following resistance training programs are influenced by training intensity (Fry, 2004; Maszczyk et al., 2020). Traditional resistance exercises (e.g. free weight, weight stack machines), where the same absolute load is lifted and lowered, may not provide an optimal stimulus for eccentric (ECC) actions. Due to the greater force production capacity of ECC compared with concentric (CONC) actions, the use of the same absolute load lead to a lowered stimulus for ECC actions (Sogaard et al., 1996). This issue theoretically places traditional resistance exercises in disadvantage compared with other resistance training. Due to the benefits of ECC actions in neuromuscular adaptations, flywheel resistance training emerged as an effective way to enhance strength and power adaptations (Maroto-Izquierdo et al., 2017; Chen et al., 2018). When performed properly, flywheel exercises allow for higher ECC than CONC force values to be generated, leading to brief episodes of eccentric overload (EO) (Norrbrand et al., 2008).

The increased popularity of flywheel devices resides in their efficacy to increase muscular strength (Askling et al., 2003; Norrbrand

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et al., 2010) and power (Maroto-Izquierdo et al., 2016), as well as hypertrophy adaptations (Norrbrand et al., 2008) in healthy and well-trained populations. In addition, flywheel resistance training has also been proposed as a useful methodology to improve dynamic athletic performance (Maroto-Izquierdo et al., 2017; Blazek et al., 2019). Sports movements demand the production of maximal power in unpredictable and variable contexts, with an emphasis on eccentric and multidirectional components (Gonzalo-Skok et al., 2017). Thus, considering the principle of specificity, exercises that accentuates force and power production during the ECC phase should be more present in resistance training workouts (Gonzalo-Skok et al., 2017).

Among flywheel devices, the conical pulley is commonly used both in practice and science (Beato et al., 2019; Fernández-Gonzalo et al., 2014; Gonzalo-Skok et al., 2017; Gonzalo-Skok et al., 2019; Timon et al., 2019). This device operates from the energy created by winding and unwinding a rope wrapped around a vertical cone-shaped shaft (Nuñez et al., 2017). In contrast to other flywheel devices, conical pulleys allow for coupled CONC and accentuated EO muscular actions at high velocities while conducting specific and multidirectional movements (Gonzalo-Skok et al., 2017; Nuñez et al., 2017). The importance of reaching EO values should be highlighted , as force increases after a flywheel training program are higher with the existence of EO during training (Nuñez and Saez de Villarreal, 2017). In conical pulley devices, the exercise intensity can be adjusted through two different modes: (a) by adding or removing any number of the 16 weights located on the edge of the flywheel; and (b) by selecting one of the four height levels that will change the location of the pulley, height level 1 being the upper position (where the rope winds around the narrowest diameter of the cone) and level 4 being the lowest position (wider part of the cone) (Moras et al., 2018; Moras et al., 2019). Although not reported in most studies, the selection of the height level influences the geometrical factor (i.e. radius) of the conical pulley, which consequently affects force production (Norrbrand et al., 2008).

The inertial load used during flywheel exercises is usually reported in the articles, and several researches have shown the influence of using different inertial loads on force and power output performance during flywheel resistance exercises (Martínez-Aranda et al., 2017; Piqueras-Sanchiz et al., 2019; Sabido et al., 2018; Vazquez-Guerrero et al., 2016). Specifically, light inertial loads allow for greater CONC and ECC power output to be produced, whereas EO (eccentric/concentric ratio) is maximized when using high loads. Further, Sabido et al. (2019) showed beneficial performance adaptations (e.g. linear sprint and change of direction ability) following a flywheel training intervention based on light (0.025 kg·m^2) vs high (0.075 kg·m^2) inertial loads. However, due to the novelty in the use of conical pulleys in research, little is known about how strength and conditioning coaches can manage changes in flywheel resistance exercises through modifications of further variables. To the best of authors' knowledge, only Vazquez-Guerrero et al. (2016) studied the influence of the height level used in the conical pulley. In that study, greater velocities but lower force values were found when using a greater radius of the cone. However, power output responses to different height levels have not been analyzed in previous studies. In addition, by modifying the rope length, conical pulley exercises can be performed close or far to the device. Whether this variable may affect power output has not previously been analyzed. Therefore, based on the scarcity of research regarding alternative variables (i.e. rope length and height level), and the potential influence of these variables on power output responses, the aim of this study was to analyze the influence of using three different rope lengths and four different height levels during conical pulley resistance exercises on concentric peak power, eccentric peak power and EO. We hypothesized that using lower positions of the conical pulley, greater concentric and eccentric power output can be achieved. In addition, the authors hypothesized that power output will increase when using longer rope lengths.

Methods

Experiment 1: Rope length

Participants

Fourteen recreationally trained participants took part in this experiment: nine men (age: 29.4 ± 7.2 years; weight: 75.8 ± 6.8 kg;

height: 1.75 ± 0.02 m) and five women (age: 27.8 ± 5.7 years; weight: 63.6 ± 3.2 kg; height: 1.68 ± 0.03m). All participants were recreational athletes from different sports (e.g. soccer, handball, tennis), and reported at least two years' experience in resistance training, including the row exercise. None of them reported previous experience with flywheel exercises. All participants were carefully informed about the potential risk of the testing sessions and signed a written informed consent approved by the Ethics Committee of the University in accordance with the Declaration of Helsinki (2013) before participation. Participants were informed that they were able to voluntarily withdraw from the study at any moment. To avoid experimental variability, the same researcher conducted all testing sessions, and subjects were scheduled at the same time for each session. Throughout the investigation, participants were requested to maintain their regular diets and normal hydration state, not to take any nutritional supplementation or anti-inflammatory medications, and to refrain from caffeine intake in the 3 hours before each testing session. Strength training sessions were not allowed at least 72 hours before the experimental sessions.

Procedures

Two weeks prior to the test, the participants conducted two familiarization sessions (one per week) aiming to learn the protocol and the correct technique to perform the exercise in the conical pulley device. A previous study with flywheel devices reported that two familiarization sessions are required before finding reliable and stable power output values during flywheel exercises (Sabido et al., 2017). Both familiarization and testing sessions consisted of three sets of ten repetitions of the seated row exercise using a conical pulley device. Before testing, all participants completed a general warm-up, including 5 minutes of jogging and dynamic stretching. Afterwards, a more specific warm-up consisting of a barbell row set of 10 submaximal repetitions, and one set of the seated row exercise with the conical pulley was performed. Participants were seated in an adjustable fitness chair leaning the chest on the backrest to facilitate stabilization of the body, with the knee joint bent at a 90-degree angle, the back flat in a neutral vertical position and a pronated grip for the handle. Execution of the exercise proceeded by the subject making a full elbow flexion in the CONC phase and a full extension in the ECC one. During the whole movement, participants were required to keep the chest in contact with the chair. Within each session, all participants performed one set of 10 repetitions with each of the different rope lengths (1.5, 2.5 and 3.5 m) in a random order. During this protocol, the height level employed in the conical pulley remained fixed (at level 1), and the mass consisted of 6 loads of 900 grams each, resulting in an inertial load of 0.15 kg·m^2. Subjects were fully encouraged to perform the CONC phase at a maximal velocity, and to try to perform a sudden braking action at the end of the ECC phase. Three minutes of recovery time was established between sets.

The conical pulley included an optical receiver (SmartCoach, Europe AB, Stockholm, Sweden) coupled to the device, recording data of each repetition in both the CONC and ECC phase of the movement. Then, a specialized software (SmartCoach Power Encoder, Europe AB, Stockholm, Sweden) was used to process all data, using the variables concentric peak power (PP_{conc}), eccentric peak power (PP_{ecc}) and eccentric overload (EO; eccentric/concentric ratio) for analysis. A high reliability of this encoder has been previously reported (Sabido et al., 2017). Data included for analysis were the mean of all the repetitions of the set (Sabido et al., 2017).

Experiment 2: Height level

Participants

Fifteen recreationally trained males (age: 22.0 ± 1.3 years; weight: 73.5 ± 7.6 kg; height: 1.77 ± 0.04 m) were involved in the second experiment. All participants were recreational soccer players from the University team. Participants reported at least 2 years' experience in resistance training, although none of them had experience in flywheel training. All methodological issues were the same as reported in the 'Participants' section of Experiment 1.

Procedures

Participants were required to attend a total of four testing sessions (one per week), consisting of four sets of ten repetitions (one set per each height level) of the stand-up row exercise (pronated grip) using the conical pulley device. Due to the previously published necessity of a familiarization process with flywheel devices (Sabido et al., 2017; Tous-Fajardo et al., 2006), data used for analysis were from the fourth testing session. During this experiment, both inertial load (6 loads) and rope length were unmodified. Nevertheless, each set was performed using a different height level (1, 2, 3 and 4) in the conical pulley (Figure 1). There were 5 cm distances between each height level. To avoid potential cumulative fatigue effects, subjects were divided into an 'ascending order' (starting from the bottom of the cone: height level 4) and a 'descending order' (starting from the top of the cone: height level 1) group (Sabido et al., 2017). In addition, 3 minute rest intervals were allowed between sets.

The stand-up row exercise was performed starting with a full elbow extension position. Then, participants were required to pull the handle until the bar touched the chest at a height below the nipples. Additionally, to prevent imbalance during the movement execution, a stable rigid support was placed in front of the subjects, allowing them to firmly place their feet. As in Experiment 1, participants were instructed to perform the CONC phase as fast as possible and to delay the braking action to the last part of the ECC phase. Likewise, mechanical data were recorded and analyzed by the specialized software (SmartCoach), using PP_{conc}, PP_{ecc} and EO for analysis.

Statistical analysis

All data were analyzed using the statistical package SPSS 22.0 (SPSS Inc, Chicago, IL, USA). After testing the normality of the data using a Kolmogorov−Smirnov test, a one-way ANOVA was used to analyze differences in the different variables (PP_{conc}, PP_{ecc}, and EO) when using the four different height levels. The same procedure was used for analyzing data regarding rope length. Statistical significance was set at $p < .05$. In addition, the magnitude of the differences was calculated using Cohen's d and interpreted for a recreationally trained sample (1−5 years' experience in resistance training) following Rhea (2004), as $d < 0.35$ (trivial); $d = 0.35–0.8$ (small); $d = 0.8−1.50$ (moderate); $d > 1.5$ (large).

Results

Experiment 1: Rope length

Data of PP_{conc}, PP_{ecc} and EO with the different rope lengths are shown in Table 1. Non-significant differences were found for any variable. Nevertheless, there was a trend for significantly higher PP_{ecc} values as the rope length increases (small ES). Similarly, EO was close to significance when comparing length 1 (1.5 m) with length 3 (3.5 m) ($p = .056$; ES = 0.41; small).

Experiment 2: Height level

Data of PP_{conc} when using each of the four height levels in the pulley are shown in Figure 2. The highest position of the pulley (level 1) caused significantly lower values than level 2 (480 ± 155 vs 576 ± 172 W; ES = 0.59; small), level 3 (480 ± 155 vs 678 ± 246 W; $p < .001$; ES = 0.96; moderate) and level 4 (480 ± 155 vs 760 ± 245 W; $p < .001$; ES = 1.37; moderate). In addition, PP_{conc} in level 4 was significantly higher than in level 3 ($p = .037$; ES = 0.33; trivial) and level 2 ($p < .001$; ES = 0.87; moderate). The difference in PP_{conc} between levels 2 and 3 was close to significance ($p = .055$; ES = 0.48; small).

The values of PP_{ecc} with each height level are shown in Figure 3. When using level 1, significantly lower PP_{ecc} values were found compared with level 3 (602 ± 341 vs 717 ± 293 W; $p = .014$; ES = 0.36; small) and level 4 (602 ± 341 vs 766 ± 258 W; $p = .012$; ES = 0.54; small). In addition, significantly higher values were found when using the level 4 compared with the level 2 (766 ± 258 vs 649 ± 256 W; $p = .015$; ES = 0.46; small).

Conversely, for EO (eccentric/concentric ratio), the higher values were found in level 1, being significantly greater than those in levels 2 (1.22 ± 0.27 vs 1.11 ± 0.16; $p = .046$; ES = 0.50; small), 3 (1.22 ± 0.27 vs 1.06 ± 0.18; $p = .002$; ES = 0.70; small) and 4 (1.22 ± 0.27 vs 1.01 ± 0.13; $p = .002$; ES = 0.99; moderate). In addition, EO values in level 2 were significantly higher than in level 4 (1.11 ± 0.16 vs 1.01 ± 0.13; $p = .009$; ES = 0.69; small), and close to significance compared with level 3 (1.11 ± 0.16 vs 1.06 ± 0.18; $p = .053$; ES = 0.29; trivial).

Discussion

The present study aimed to assess the influence of two different modifiable variables (rope length and height level) on power output during two flywheel resistance exercises using a conic pulley device. The main finding of the first experiment was the lack of significant differences in PP_{conc}, PP_{ecc} and EO when using rope lengths of either 1.5, 2.5 or 3.5 m. Nevertheless, a trend for increases in PP_{ecc} and EO (small ES) was found with greater rope lengths. The second experiment provided important information about the meaningful influence of the height level used in the conic pulley. Thus, significantly higher values of PP_{conc} (760 vs 460 W) and PP_{ecc} (766 vs 602 W) were found when comparing the lowest with the highest position of the cone. In contrast, the greater EO values were found when using the highest position of the cone (1.22 vs 1.01).

Table 1

Data of PP_{conc}, PP_{ecc} and EO by rope length.

Variable	Length 1	ES 1vs2 (90% CI)	Length 2	ES 2vs3 (90% CI)	Length 3	ES 1vs3 (90% CI)
PP_{conc} (W)	360±120	-0.16 (-0.87, 0.56)	378±107	0.01 (-0.71, 0.73)	373±92	-0.12 (-0.83, 0.60)
PP_{ecc} (W)	423±143	-0.38 (-1.09, 0.35)	479±153	0.05 (-0.67, 0.76)	472±127	-0.36 (-1.07, 0.37)
EO	1.18±0.20	-0.40 (-1.11, 0.34)	1.27±0.25	0.04 (-0.65, 0.74)	1.26±0.19	-0.41 (-1.12, 0.32)

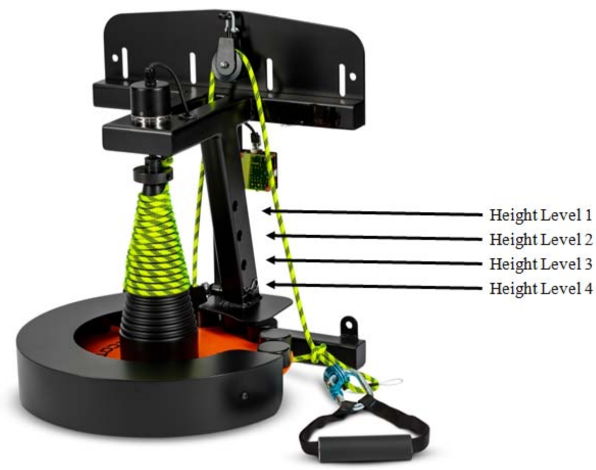

Figure 1

The conical pulley and the position of the four different height levels.

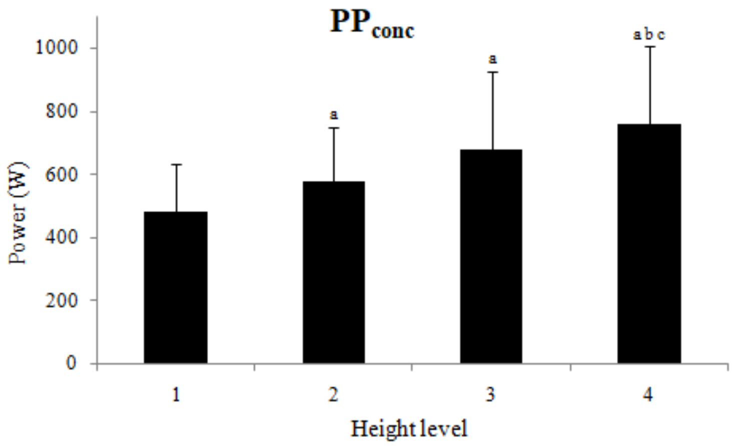

Figure 2

Data of PP$_{conc}$ by height level.
a = significantly higher than level 1; b = significantly higher than level 2;
c = significantly higher than level 3.

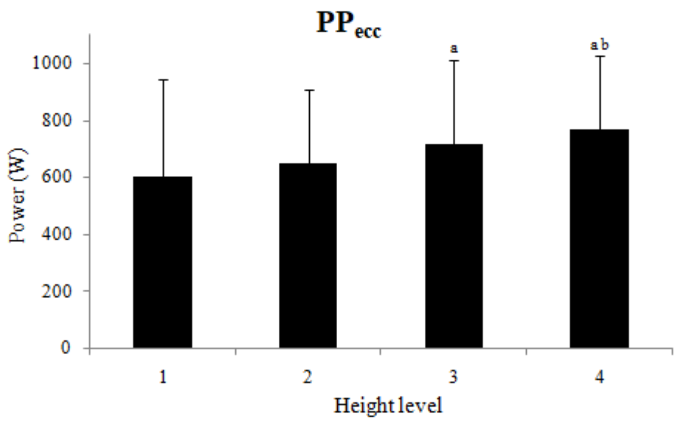

Figure 3

Data of PP$_{ecc}$ by height level.
a = significantly higher than level 1; b = significantly higher than level 2.

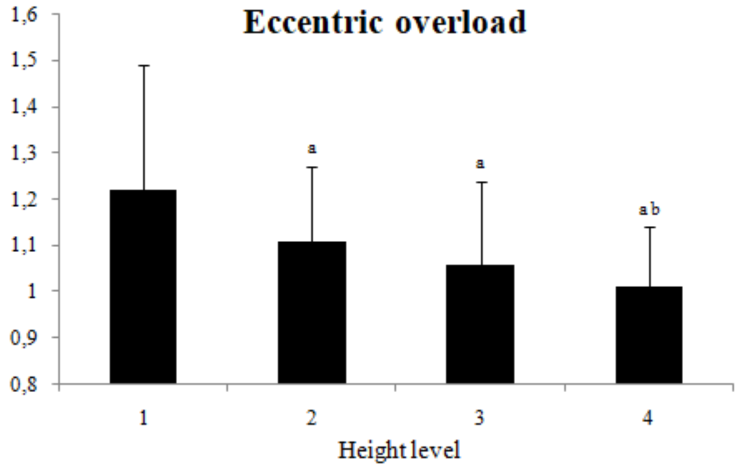

Figure 4

Data of EO (eccentric/concentric ratio) by height level.
a = significantly lower than level 1; b = significantly lower than level 2.

Among the different variables that may affect power output when using these devices, including the inertial load used and the geometric (diameter and thickness) properties of the flywheel (De Hoyo et al., 2015), variables such as rope length and the height level in the conic pulley have received little attention. To the best of our knowledge this is the first study evaluating the influence of using different rope lengths during a flywheel resistance exercise on power output. The results showed a trend for greater PPecc and EO values as the rope length increased from 1.5 to 3.5 m, with small effect sizes ranging from 0.36 to 0.45. Even when using the same height level in the conical pulley, the rope length slightly influenced the position of where the rope winds and unwinds. Specifically, a greater length would lead the rope to be wound in a lower position of the cone, which presents a greater diameter. It could be hypothesized that this greater diameter allows for a greater linear movement velocity (Vázquez-Guerrero et al., 2016), favoring to some extent the higher values of PPecc and, as a consequence, the increases in EO values. However, in spite of the great difference in the rope length used (1.5 vs 3.5 m) differences in power output and EO values did not reach statistical significance. Therefore, it seems that variations in rope length are not a key factor when using flywheel exercises.

The use of flywheel exercises allows for different ways to change the resistance to the movement offered by the device. Previous researches have already shown how both force and power output are affected by the inertial load used (Martínez-Aranda et al., 2017; Sabido et al., 2018). Nevertheless, only one previous study (Vázquez-Guerrero et al., 2016) has investigated the effect of the position (height) of where the rope winds/unwinds in the conical pulley on force production. This previous study showed that higher mean and peak forces were produced when using higher positions of the cone. The authors highlighted that, without modifying the height level, a change in the moment of inertia higher than a 55% is needed to significantly modify power output, whereas changing only one height level led to significant power output changes. These results emphasized the importance of height level management to obtain different power output responses. Similarly, the results of the present study showed a significant influence of the height used in all the variables measured (PPconc, PPecc and EO). In particular, PPconc is the variable most affected by the height used, the lowest position (corresponding with the greater cone diameter) being where greater PPconc values were obtained. Further, it seems that a quite linear relationship exists between the change in the pulley height and changes in PPconc, increasing this PPconc by approximately 15% as the pulley is placed in the next (wider) position. Similarly, PPecc also increased when lower heights of the pulley were used (Figure 3). Nevertheless, the slope of the changes when modifying the height levels seems to be less pronounced. Specifically, in the present study, PPecc increased by approximately 8% as the pulley was placed in the next (wider) position. This almost linear relationship between changes in the height level and modifications in power output may be used by coaches to accurately prescribe flywheel training. Thus, by modifying the height position of the pulley and using wider cone diameters, athletes can perform not only faster movements, but also actions producing higher power outputs. This last fact may have consequences for dynamic athletic performance, as a previous research (Sabido et al., 2019) has shown favorable results in linear sprint and change of direction performance when using flywheel devices configured to allow higher velocities and PP values (i.e. low inertial loads) compared with lower velocities (i.e. high inertial loads). A potential explanation of the superior usefulness of flywheel devices configured to allow for greater velocities may be linked to velocity specificity of resistance exercise (Behm and Sale, 1993). Thus, the faster the movement performed in the flywheel exercise is, the greater the transference to explosive actions.

Contrarily to peak power values, EO was significantly greater when using higher positions of the conical pulley. Thus, when the rope is wound/unwound in the narrowest (smaller diameter) part of the cone, greater EO values can be achieved. A potential explanation for the greater EO values when using small diameters may be the lower movement velocities reached. These lower velocities allowed the subjects to perform a longer muscle action, allowing to greater force values to be achieved. Using greater height levels in the pulley entail similar responses as increasing the inertial load, causing lower PP values, but increasing EO (Sabido et al., 2018). Although greater PP output could be useful for more functional-oriented exercises, greater EO values may be a key factor for muscular adaptations. The ability to produce great eccentric forces at long muscle lengths (as when using flywheel devices) has been linked to greater hypertrophy effects (Noorkoiv et al., 2014). Consequently, it can be hypothesized that the use of higher positions in the conical pulley may be a more effective option when looking for muscular hypertrophy. In this line, increases in electromyographic activity as well as in muscle cross section area has been previously reported following flywheel training (Norrbrand et al., 2008; Tous-Fajardo et al., 2006). Further, a review of flywheel training has shown that increases in force are higher with the existence of greater EO values (Nuñez-Sanchez and Saez de Villarreal, 2017). Thus, when aiming to develop muscular strength, the use of higher positions of the conical pulley would be a better choice.

Conclusions

The results of the present study provide important information to optimize the use of flywheel resistance devices. By increasing the rope length during an exercise, slightly greater PPecc and EO values can be achieved, although not significant differences were found. Nevertheless, the factor influencing greater PPconc, PPecc and EO is the height level used in the conic pulley. Specifically, bottom positions of the cone (great diameters) allow for greater PPconc and PPecc to be produced, while top positions (small diameters) caused greater EO values. Strength and conditioning coaches can use data provided in the present study for prescribing flywheel resistance exercises according to the aim of the training session. Thus, within a resistance training periodization, conical pulley exercises should be performed using a higher position, when aiming to greater force and hypertrophy adaptations. However, in training periods close to competitions, the use of lower positions of the cone is recommended, as they allow for greater peak power output.

References

Askling C, Karlsson J, Thorstensson A. Hamstring injury occurrence in elite soccer players after strength training with eccentric overload. *Scand J Med Sci Sports,* 2003; 13: 244-250.

Beato M, Madruga-Parera M, Piqueras-Sanchiz F, Moreno-Pérez V, Romero-Rodriguez D. Acute effect of eccentric overload exercises on change of direction performance and lower-limb muscle contractile function. *J Strength Cond Res,* 2019.

Behm DG, Sale DG. Velocity specificity of resistance training. *Sports Med*, 1993; 15: 374-388.

Blazek D, Stastny P, Maszczyk A, Krawczyk M, Matykiewicz P, Petr M. Systematic review of intra-abdominal and intrathoracic pressures initiated by the Valsalva manoeuvre during high-intensity resistance exercises. *Biol Sport*, 2019; 36(4): 373-386

Chen CH, Chen YS, Wang YT, Tseng WC, Ye X. Effects of preconditioning hamstring resistance exercises on repeated sprinting-induced muscle damage in female soccer players. *Biol Sport*, 2018; 35(3): 269-275

Cormie P, McGuigan MR, Newton RU. Developing maximal neuromuscular power. *Sport Med*, 2011; 41: 125-146.

de Hoyo M, de la Torre A, Pradas F, Sañudo B, Carrasco L, Mateo-Cortes J, Domínguez-Cobo S, Fernandes O, Gonzalo-Skok O. Effects of eccentric overload bout on change of direction and performance in soccer players. *Int J Sports Med,* 2015; 36: 308-314.

de Hoyo M, Sañudo B, Carrasco L, Mateo-Cortes J, Domínguez-Cobo S, Fernandes O, Del Ojo JJ, Gonzalo-Skok, O. Effects of 10-week eccentric overload training on kinetic parameters during change of direction in football players. *J Sports Sci*, 2016; 34: 1380-1387.

de Hoyo M, Sañudo B, Carrasco L, Domínguez-Cobo S, Mateo-Cortes J, Cadenas-Sánchez MM, Nimphius S. Effects of traditional versus horizontal inertial flywheel power training on common sport-related tasks. *J Hum Kinet*, 2015; 47: 155-167.

Douglas J, Pearson S, Ross A, McGuigan M. Chronic adaptations to eccentric training: a systematic review. *Sports Med*, 2016; 47: 917-941.

Fernandez-Gonzalo R, Lundberg TR, Alvarez-Alvarez L, De Paz JA. Muscle damage responses and adaptations to eccentric-overload resistance exercise in men and women. *Eur J Appl Physiol,* 2014; 114: 1075-1084.

Fry AC. The role of resistance exercise intensity on muscle fibre adaptations. *Sports Med*, 2004; 34: 663-679.

Gonzalo-Skok O, Tous-Fajardo J, Valero-Campo C, Berzosa C, Bataller AV, Arjol-Serrano JL, Moras G, Mendez-Villanueva A. Eccentric-overload training in team-sport functional performance: constant bilateral vertical versus variable unilateral multidirectional movements. *Int J Sports Physiol Perform*, 2017; 12: 951-958.

Gonzalo-Skok O, Moreno-Azze A, Arjol-Serrano JL, Tous-Fajardo J, Bishop C. A comparison of three different unilateral strength training strategies to enhance jumping performance and decrease inter-limb assymetries in soccer players. *Int J Sports Physiol Perf,* 2019; 6: 1256-1264.

Martínez-Aranda LM, Suárez-Arrones LM. Effects of inertial settings on power, force, work and eccentric overload during flywheel resistance exercise in women and men. *J Strength Cond Res,* 2017; 31: 1653-1661.

Maroto-Izquierdo S, García-López D, de Paz JA. Functional and muscle-size effects of flywheel resistance training with eccentric-overload in professional handball players. *J Hum Kinet*, 2017; 60: 133-143.

Maroto-Izquierdo S, García-López D, Fernandez-Gonzalo R, Moreira OC, González-Gallego J, de Paz JA. Skeletal muscle functional and structural adaptations after eccentric overload flywheel resistance training: a systematic review and meta-analysis. *J Sci Med Sport*, 2017; 20: 943-951.

Maszczyk A, Wilk M, Krzysztofik M, et al. The effects of resistance training experience on movement characteristics in the bench press exercise. *Biol Sport*, 2020; 37(1): 79-83

Moras G, Fernández-Valdés B, Vázquez-Guerrero J, Tous-Fajardo J, Exel J, Sampaio J. Entropy measures detect increased movement variability in resistance training when elite rugby players use the ball. *J Sci Med Sports*, 2018; 21: 1286-1292.

Moras G, Vázquez-Guerrero J, Fernández-Valdés B, Rosas-Casals M, Weakley J, Jones B, Sampaio J. Structure of force variability during squats performed with an inertial flywheel device under stable versus unstable surfaces. *Hum Mov Sci*, 2019; 66: 497-503.

Noorkõiv M, Nosaka K, Blazevich AJ. Neuromuscular adaptations associated with knee joint angle-specific force change. *Med Sci Sports Exerc* 2014; 46: 1525-1537.

Norrbrand L, Fluckey JD, Pozzo M, Tesch PA. Resistance training using eccentric overload induces early adaptations in skeletal muscle size. *Eur J Appl Physiol*, 2008; 102: 271-281.

Nuñez F, de Hoyo M, López A, Sañudo B, Otero-Esquina C, Sanchez H, Gonzalo-Skok O. Eccentric-concentric ratio: a key factor for defining strength training in soccer. *Int J Sports Med*, 2019; 40: 796-802.

Nuñez FJ, Sáez de Villarreal E. Does flywheel paradigm training improve muscle volume and force? A Meta-Analysis. *J Strength Cond Res*, 2017; 31: 3177-3186.

Núñez FJ, Suarez-Arrones LJ, Cater P, Mendez-Villaneva A. The high-pull exercise: a comparison between a versapulley flywheel device and the free weight. *Int J Sports Physiol Perform*, 2017; 12: 527-532.

Piqueras-Sanchiz F, Martín-Rodríguez S, Martínez-Aranda LM, Ribeiro-Lopes T, Raya-González J, García-García O, Nakamura FY. Effects of moderate vs. high iso-inertial loads on power, velocity, work and hamstring contractile function after flywheel resistance exercise. *PLoS One*, 14: e0211700, 2019.

Rhea MR. Determining the magnitude of treatment effects in strength training research through the use of the effect size. *J Strength Cond Res*, 2004; 18: 918–920.

Sabido R, Hernández-Davó JL, Pereira-Gerbert GT. Influence of different inertial loads on basic training variables during the flywheel squat exercise. *Int J Sports Physiol Perf*, 2018; 13: 482-489.

Sabido R, Pombero L, Hernández-Davó JL. Differential effects of low vs high inertial loads during an eccentric-overload training intervention in rugby union players: A preliminary study. *J Sports Med Phys Fitness*, 2019; 59: 1805-1811.

Søgaard K, Christensen H, Jensen BR, Finsen L, Sjøgaard G. Motor control and kinetics during low level concentric and eccentric contractions in man. *Electroencephalogr Clin Neurophysiol*, 1996; 101: 453-460.

Timon R, Allemano S, Camacho-Cardeñosa M, Camacho-Cardeñosa A, Martinez-Guardado I, Olcina G. Post-activation potentiation on squat jump following two different protocols: traditional vs. inertial flywheel. *J Hum Kinet*. 2019; 69: 271-281.

Tous-Fajardo J, Maldonado RA, Quintana JM, Pozzo M, Tesch PA. The flywheel leg curl machine: offering eccentric overload for hamstring development. *Int J Sports Physiol Perf*, 2006; 1: 293–298.

Vázquez-Guerrero J, Moras G, Baeza J, Rodríguez-Jiménez S. Force outputs during squats performed using a rotational inertia device under stable versus unstable conditions with different loads. *PLoS One*, 2016; 11: e0154346.

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