Effects of 12-week lower-limb power training using two cluster-set configurations in young adults: A randomized controlled trial

Efeitos de 12 semanas de treino de potência dos membros inferiores com duas configurações de séries em cluster em jovens adultos: Um ensaio clínico randomizado

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Abstract

Aim: This study investigated the effects of two lower-limb cluster-set configurations on maximal strength, muscle power, and movement velocity over 12 weeks of power-oriented resistance training in young adults.

Methods: Thirty recreationally active individuals (17 women; 13 men) were randomly assigned to one of three groups: a control group (CG), Cluster 1 (CL1), or Cluster 2 (CL2). Participants completed baseline, 4-week, 8-week, and 12-week assessments, including one-repetition maximum (1-RM) squat, maximal muscle power in countermovement jump (CMJ) and countermovement sprint (CMS), vertical jump performance, and 20-m sprint velocity. CL1 performed two blocks of three sets of five repetitions with 20-s intra-set and 50-s inter-set rest, whereas CL2 completed three blocks of five sets of two repetitions with 10-s intra-set and 20-s inter-set rest. Both clusters matched total repetitions and total recovery time. Training was conducted using a pneumatic resistance device in thrice-weekly sessions.

Results: Both cluster protocols elicited significant intra-group improvements in 1-RM strength, CMJ and CMS peak power, and combined velocity measures across the training period. Inter-group differences at post-training favored CL2 over CG for CMJ, and both CL1 and CL2 over CG for CMS and velocity. Effect sizes indicated moderate improvements in power and small improvements in velocity for both training structures.

Conclusion: Twelve weeks of power training using cluster sets improved strength, power, and movement velocity in recreationally active young adults. Structures employing a higher number of repetitions per cluster appear more advantageous for maximal strength, whereas configurations with fewer repetitions may enhance power and velocity earlier in the training period. Both formats are viable strategies for programming power-oriented resistance training.

Keywords: Cluster Sets; Neuromuscular Performance; Power Training; Resistance Training; Velocity-Based Outcomes.

Resumo

Objetivo: Este estudo investigou os efeitos de duas configurações de séries em *cluster* para os membros inferiores na força máxima, na potência muscular e na velocidade de movimento ao longo de 12 semanas de treino de resistência orientado para a potência em jovens adultos.

Métodos: Trinta indivíduos recreacionalmente ativos (17 mulheres; 13 homens) foram aleatoriamente distribuídos por um de três grupos: grupo controlo (GC), Cluster 1 (CL1) ou Cluster 2 (CL2). Os participantes realizaram avaliações no momento basal, às 4, 8 e 12 semanas, incluindo o teste de uma repetição máxima (1-RM) no agachamento, potência muscular máxima no salto com contramovimento (SCM) e no sprint com contramovimento (SCpM), desempenho no salto vertical e velocidade no sprint de 20 m. O CL1 realizou dois blocos de três séries de cinco repetições, com 20 s de descanso intra-série e 50 s de descanso inter-séries, enquanto o CL2 completou três blocos de cinco séries de duas repetições, com 10 s de descanso intra-série e 20 s de descanso inter-séries. Ambos os protocolos em *cluster* igualaram o número total de repetições e o tempo total de recuperação. O treino foi realizado com um dispositivo de resistência pneumática, em sessões três vezes por semana.

Resultados: Ambos os protocolos em *cluster* induziram melhorias intra-grupo significativas na força 1-RM, na potência máxima do SCM e do SCpM, bem como nas medidas combinadas de velocidade ao longo do período de treino. As diferenças inter-grupos no pós-treino favoreceram o CL2 em relação ao GC no SCM, e tanto o CL1 como o CL2 em relação ao GC no SCpM e na velocidade. Os tamanhos do efeito indicaram melhorias moderadas na potência e pequenas melhorias na velocidade para ambas as estruturas de treino.

Conclusão: Doze semanas de treino de potência utilizando séries em *cluster* melhoraram a força, a potência e a velocidade de movimento em jovens adultos recreacionalmente ativos. Estruturas que empregam um maior número de repetições por *cluster* parecem ser mais vantajosas para a força máxima, enquanto configurações com menos repetições podem potenciar ganhos de potência e velocidade mais precoces ao longo do período de treino. Ambos os formatos constituem estratégias viáveis para a programação do treino de resistência orientado para a potência.

Palavras-Chave: Desempenho Neuromuscular; Resultados Baseados na Velocidade; Séries em *Cluster*; Treino de Potência; Treino de Resistência.

1. Introduction

Resistance training (RT) prescription requires strategic manipulation of variables such as volume, intensity, rest intervals, and set configuration to optimize adaptations according to the practitioner's goals. Traditionally, RT programs employ continuous repetitions within each set, followed by a fixed inter-set recovery period to restore homeostasis and sustain performance in subsequent sets (Haff & Triplett, 2016). However, alternative set structures—particularly cluster sets—have gained attention for their capacity to redistribute rest within the set, thereby reducing neuromuscular fatigue and improving movement quality (Tufano et al., 2017).

Continuous repetitions typically impose greater metabolic stress by increasing reliance on the glycolytic pathway, leading to elevated blood lactate, hydrogen ion accumulation, and reduced intramuscular pH. These responses contribute to declines in force production and velocity associated with peripheral fatigue (Girard et al., 2021; McCaulley et al., 2020). In contrast, cluster sets incorporate short intra-set rest periods, which facilitate partial phosphocreatine resynthesis and metabolite clearance, allowing athletes to maintain higher power output across repetitions (Haischer et al., 2021; Vecchio et al., 2022).

Recent investigations highlight that cluster configurations may attenuate velocity loss, enhance repetition quality, and potentiate training adaptations, particularly in power-oriented programs (Davies et al., 2021; García-Ramos

et al., 2020). Studies comparing traditional and cluster structures report acute benefits for force–velocity characteristics, endocrine responses, and kinetic outputs (Tufano et al., 2019; Oliver et al., 2015). However, chronic adaptations—particularly those related to lower-limb muscle power—remain less understood, as most studies have focused on strength or hypertrophy outcomes rather than longitudinal power development (Davies et al., 2023).

Current guidelines from the American College of Sports Medicine recommend three to six repetitions with high intent to maximize power development (American College of Sports Medicine, 2021). Nonetheless, cluster sets using singles, doubles, or triples are frequently adopted in practice to minimize fatigue and preserve movement velocity (Weakley et al., 2020; Banyard et al., 2021). Despite their increasing popularity, little is known about how different cluster structures—especially those differing in repetition count and intra-set rest duration—affect long-term adaptations in muscle power and movement velocity.

This knowledge gap has important implications for coaches and practitioners, as training structures emphasizing either glycolytic or ATP–PC energetic contributions may yield distinct chronic outcomes. Understanding which cluster configuration elicits superior improvements in strength, power, and speed is essential for designing individualized programs that maximize performance.

Therefore, the purpose of the present study was to compare the effects of 12 weeks of lower-limb power training using two distinct cluster-set structures on maximal strength, muscle power, and movement velocity in young adults. We hypothesized that both structures would produce comparable improvements after the training period.

2. Methods

2.1. Participants

This randomized controlled trial included 30 recreationally active young adults (17 women and 13 men) aged 20–35 years. Eligibility criteria required participants to: (a) have at least one year of resistance training (RT) experience, but be detrained for the preceding 6–12 months; (b) be free from musculoskeletal injuries; (c) for women, not be using oral contraceptives; (d) refrain from performing power-oriented training; and (e) engage in recreational sports at least twice weekly. Exclusion criteria included the use of any ergogenic aids such as anabolic steroids, pre-workout supplements, or protein supplements that could potentially influence performance outcomes. Body mass and height were assessed using a mechanical scale with an attached stadiometer (Filizola Model 31, São Paulo, Brazil). Baseline characteristics for each group are presented in Table 1. All participants completed the Physical Activity Readiness Questionnaire (PAR-Q) and provided written informed consent. The study complied with the Declaration of Helsinki and Brazilian Resolution 466/2012 for human research. Ethical approval was granted by the institutional Research Ethics Committee.

2.2. Experimental Design and Familiarization

Participants attended an initial orientation session, during which procedures, risks, and benefits were explained. A two-week familiarization period followed, consisting of two weekly sessions involving the exercises and the one-repetition maximum (1-RM) testing protocol. Familiarization is widely recommended to reduce learning effects and improve measurement reliability in neuromuscular performance tests (Grgic et al., 2020). During this period, participants practiced the countermovement jump (CMJ) and countermovement sprint (CMS) using a pneumatic resistance system (Keiser Functional Trainer, Keiser Sports Health Equipment, Fresno, CA, USA). They were also familiarized with vertical jump (VJ), horizontal impulse, and 20-m sprint testing procedures.

2.3. Maximal Strength and Power Assessments

2.3.1. 1-RM Testing

The 1-RM squat was performed on a Smith machine following standardized guidelines for strength testing reliability (Schoenfeld et al., 2021). After a general warm-up, participants executed a load progression of 40%, 50%, 70%, and 85% of their estimated 1-RM, performing 10, 6, 4, and 3 repetitions, respectively. Up to four

maximal attempts were allowed, with 5 minutes of rest between attempts. A successful lift required descending until the thighs reached a position parallel to the ground and completing full knee and hip extension.

2.3.2. Countermovement Jump and Sprint Power Tests

The maximal muscle power (MMP) test for CMJ and CMS was performed using the pneumatic Keiser system. Participants completed two sets of 15 bodyweight squats as warm-up, followed by a two-minute rest. They were then instructed to perform the highest number of maximal-intent repetitions until failure, using a high-intensity load previously established during familiarization and sufficient to prevent exceeding 20 repetitions. Peak power was automatically recorded by the machine.

2.4. Vertical Jump Assessment

Vertical jump height was assessed using the validated My Jump application for iOS devices, which has demonstrated strong validity and reliability compared with force platforms (Balsalobre-Fernández et al., 2015; Gallardo-Fuentes et al., 2016). Participants began in an upright stance, performed a rapid countermovement to approximately 90° of knee flexion, and executed a maximal jump. Three attempts were allowed with one-minute rests. Jump height was calculated using flight time ($h = t^2 \times 1.22625$). The highest value was used for analysis.

Output velocity was derived from the conservation of energy equation, assuming equivalence between potential and kinetic energy at takeoff.

2.5. Sprint Testing

The 20-m sprint test was conducted in an indoor facility. Participants started behind the line and sprinted 20 m at maximal effort. Three attempts were performed with 3-minute rest intervals. Sprint times were recorded using a GoPro HERO 3+ Black Edition (240 Hz, 1080p), positioned perpendicular to the sagittal plane. Video analysis using Kinovea software (v.8.15) determined mean velocity (MV), 10-m velocity (V10), and final 10-m velocity (V20), following validated methods for high-speed video sprint analysis (Bond et al., 2017).

Reflective markers were placed on the greater trochanters to identify crossing of the start and finish lines.

2.6. Training Intervention

Following baseline testing, participants were randomly assigned to one of three groups:

- Control Group (CG): No training; participated only in testing sessions.
- Cluster 1 (CL1): Performed two blocks of 3 sets of 5 repetitions, with 20-s intra-set and 50-s inter-set rest.
- Cluster 2 (CL2): Performed three blocks of 5 sets of 2 repetitions, with 10-s intra-set and 20-s inter-set rest.

Both cluster structures equated total repetitions (30 per session) and total recovery time (180 s). Training used the Keiser pneumatic system and included CMJ and CMS exercises across 12 weeks, with three weekly sessions separated by 48 hours. Before each training session, participants completed a standardized warm-up consisting of two sets of 15 bodyweight squats. Load progression was individualized according to performance in periodic power tests. This strategy aligns with contemporary recommendations for velocity-based and power-oriented training (Randell et al., 2021).

2.7. Statistical Analysis

Normality of all variables was examined using the Shapiro–Wilk test. Pearson correlations were computed among velocity- and power-related variables across each time point. Variables with correlations ≥0.90 at all moments were combined to reduce redundancy. Velocity was therefore treated as a composite variable derived from the mean of VS and MV, consistent with approaches used in neuromuscular profiling research (García-Ramos et al., 2021). A mixed-model two-way ANOVA (group × time) with repeated measures was conducted for 1-RM, peak power (CMJ and CMS), and velocity. When Mauchly's test indicated violations of sphericity, the Greenhouse–Geisser correction was applied. Bonferroni post hoc tests were used for pairwise comparisons. Effect sizes (ES)

were calculated using Cohen's d, interpreted according to thresholds for recreationally trained individuals (Rhea, 2004): trivial (<0.35), small (0.35–0.80), moderate (0.80–1.50), and large (>1.50). Significance was set at $p < 0.05$. All analyses were performed in SPSS v.23.0 (IBM Corp., USA).

3. Results

All 30 participants completed the study. As presented in Table 2, takeoff velocity (VS) and mean 20-m sprint velocity (MV) were strongly correlated across all assessment points (r = 0.91–0.93). These measures were therefore averaged to obtain the composite velocity variable used in subsequent analyses.

3.1. Maximal Strength

Figure 4 presents squat 1-RM performance across the intervention. No significant between-group differences were observed ($p > 0.05$), whereas a significant main effect of time was identified ($p = 0.002$). Within both CL1 and CL2, 1-RM increased from baseline to weeks 4, 8, and 12, from week 4 to weeks 8 and 12, and from week 8 to week 12 (all $p < 0.001$).

Relative to baseline, effect sizes in CL1 were small at week 4 (d = 0.77), moderate at week 8 (d = 1.30), and large at week 12 (d = 1.77). Corresponding effect sizes in CL2 were trivial at week 4 (d = 0.29) and small at weeks 8 and 12 (d = 0.52 and 0.67, respectively). Effect sizes in CG were trivial at all follow-up assessments (d = 0.04–0.09; Table 3).

3.2. Countermovement Jump Peak Power

CMJ peak power results are presented in Figure 5. At week 12, peak power was higher in CL2 than in CG ($p = 0.024$). Within CL1, peak power increased from baseline to weeks 4, 8, and 12 ($p = 0.041$, $p = 0.001$, and $p < 0.001$, respectively). Further increases occurred from week 4 to weeks 8 and 12 and from week 8 to week 12 (all $p = 0.001$).

Within CL2, peak power increased from baseline to weeks 4, 8, and 12 ($p = 0.007$, $p = 0.018$, and $p < 0.001$, respectively). Increases were also observed from week 4 to weeks 8 and 12 ($p = 0.018$ and $p < 0.001$, respectively) and from week 8 to week 12 ($p < 0.001$; Figure 5).

As detailed in Table 3, effect sizes relative to baseline in CL1 were small at weeks 4 and 8 (d = 0.38 and 0.73, respectively) and moderate at week 12 (d = 1.43). In CL2, effect sizes were trivial at week 4 (d = 0.32), small at week 8 (d = 0.69), and moderate at week 12 (d = 1.11). Effect sizes in CG were trivial throughout the intervention (d = 0.09–0.13).

3.3. Countermovement Sprint Peak Power

Figure 5 also presents CMS peak power across the intervention. At week 12, peak power was higher in CL1 and CL2 than in CG ($p = 0.025$ and $p = 0.038$, respectively). Within CL1, increases were observed from baseline to week 12 ($p = 0.003$), from week 4 to week 8 ($p = 0.031$), and from week 4 to week 12 ($p = 0.009$).

Within CL2, peak power increased from baseline to weeks 4, 8, and 12 ($p = 0.003$, $p < 0.001$, and $p < 0.001$, respectively), with an additional increase from week 4 to week 8 ($p = 0.003$; Figure 5).

According to Table 3, effect sizes relative to baseline in CL1 were trivial at week 4 (d = 0.33), small at week 8 (d = 0.61), and moderate at week 12 (d = 0.97). In CL2, effect sizes were moderate at all follow-up assessments (d = 0.89, 1.31, and 1.21 at weeks 4, 8, and 12, respectively). Effect sizes in CG were trivial throughout the intervention (d = 0.09–0.34).

3.4. Composite Velocity

Composite velocity results are presented in Figure 6. A significant group × time interaction was observed ($p = 0.001$). At week 12, velocity was higher in CL1 and CL2 than in CG ($p = 0.039$ and $p = 0.020$, respectively).

Within CL1, velocity increased from baseline to weeks 8 and 12 (both p = 0.001) and from week 4 to weeks 8 and 12 (p = 0.008 and p = 0.016, respectively). Within CL2, increases occurred from baseline to weeks 4, 8, and 12 (p = 0.022, p = 0.001, and p = 0.001, respectively) and from week 4 to weeks 8 and 12 (p = 0.004 and p = 0.021, respectively; Figure 6).

As reported in Table 3, effect sizes relative to baseline in CL1 were small at weeks 4, 8, and 12 (d = 0.36, 0.62, and 0.71, respectively). In CL2, effect sizes were trivial at week 4 (d = 0.32) and small at weeks 8 and 12 (d = 0.50 and 0.54, respectively). Effect sizes in CG were trivial at all follow-up assessments (d = 0.01–0.17).

4. Discussion

The purpose of this study was to compare the chronic effects of two power-oriented cluster-set configurations on maximal strength, muscle power, and movement velocity in young adults. The main findings indicate that: (a) both cluster structures produced significant intra-group improvements across all performance variables; (b) CL2 demonstrated superior CMJ performance compared with the control group at post-training; and (c) both CL1 and CL2 outperformed the control group for CMS peak power and the composite velocity variable. Collectively, these results support the use of cluster sets as an effective strategy for improving neuromuscular performance during a 12-week training period.

Both cluster protocols improved 1-RM strength, with CL1 demonstrating larger effect sizes compared to CL2. This pattern aligns with evidence indicating that higher repetition schemes within cluster sets may increase mechanical tension and total time under tension—two primary drivers of strength development (Schoenfeld et al., 2021). The relatively longer intra-set rest in CL1 (20 s) may have allowed adequate phosphocreatine (PCr) replenishment while simultaneously permitting greater cumulative work per block, which could explain the superior strength gains.

Recent literature suggests that cluster sets enhance acute force maintenance compared with traditional sets, but long-term strength adaptations are influenced predominantly by total volume load and the ability to sustain high-quality repetitions (Davies et al., 2023). In this context, CL1's structure of 3 × 5 repetitions appears to have elicited a more favorable stimulus for maximal strength than the lower-repetition, higher-frequency structure used in CL2.

Both cluster formats resulted in significant improvements in CMJ and CMS peak power, with CL2 showing superior post-training CMJ performance compared with the control group. This outcome is consistent with studies demonstrating that lower repetition cluster structures (e.g., singles or doubles) allow athletes to sustain higher bar velocities and optimize power output across sets (Weakley et al., 2020; Banyard et al., 2021).

Additionally, lower-repetition clusters may attenuate metabolic stress and reduce velocity loss, preserving the high-intent movement patterns required for power training adaptations (Tufano et al., 2017). These mechanisms likely explain why CL2 achieved similar – and in some cases earlier – improvements in power compared with CL1, despite lower accumulated tension.

The moderate effect sizes observed in both groups reinforce that cluster sets are viable for chronic power development. Importantly, the use of a pneumatic resistance device may have further contributed to power gains by minimizing inertial constraints and enabling consistent force application throughout the movement (García-Ramos et al., 2020).

Velocity improvements were observed for both cluster configurations, with CL2 showing significant gains as early as week 4, whereas CL1 showed meaningful changes from week 8 onward. The earlier improvements in CL2 may reflect its design favoring repeated exposure to high-velocity contractions with minimal velocity loss — a known factor for enhancing neuromuscular efficiency and rate of force development (Cormie et al., 2011).

These findings align with velocity-based training principles, wherein maintaining ≥90% of maximal concentric velocity is believed to maximize speed-oriented adaptations through heightened motor unit recruitment and improved neuromuscular coordination (Randell et al., 2021).

From an applied standpoint, both cluster structures represent effective programming options for improving power and velocity in recreationally active individuals. However, the choice of structure may depend on the primary training objective:

Strength-oriented goals:

- CL1 (3 × 5 reps) appears more advantageous, likely due to its higher accumulated tension.

Power and velocity-oriented goals:

- CL2 (5 × 2 reps) may be preferable, given its ability to maintain movement quality and achieve earlier increases in velocity.

Coaches may also cycle both structures across mesocycles to emphasize different motor qualities throughout training phases.

This study has some limitations. First, the sample consisted of recreationally active young adults, which limits generalizability to trained athletes or clinical populations. Second, only two cluster configurations were tested; other formats (e.g., single repetitions, variable-rest clusters) may produce different response magnitudes. Finally, the use of a pneumatic device, while advantageous for power assessment, may limit direct comparisons with free-weight training.

Future research should explore sex-specific responses, investigate acute fatigue markers longitudinally, and examine how cluster structures influence tendon stiffness, rate of force development, and neuromuscular activation.

This study demonstrates that 12 weeks of power-oriented training using cluster sets improves maximal strength, muscle power, and movement velocity in young adults. Higher-repetition clusters may favor strength development, whereas lower-repetition clusters enhance power and velocity earlier in the training process. Both configurations are effective, and their application should be aligned with specific performance goals.

5. Limitations and Implications for Interpretation

Each group included only 10 participants, who were selected through convenience sampling. Participants were recreationally active adults with previous resistance training experience but a recent period without such training. The findings cannot be generalized directly to currently trained athletes, older adults, or clinical populations.

Trial registration information and the study protocol were unavailable; therefore, the prespecification of outcomes and analyses could not be assessed. Although study completion was reported for all participants, detailed adherence, concomitant exercise, dietary practices, and adverse event monitoring were not described.

Intervention dose remains uncertain because weekly frequency was documented inconsistently as two or three sessions, the reference for the illustrated progression of 80%, 85%, and 90% was unclear, and the stated recovery total of 180 s was not supported by a complete accounting of intervals. These issues prevent a definitive estimate of cumulative exposure and comparison of actual training dose between configurations. Resolution requires contemporaneous training records; their absence from this report restricts reproducibility.

The composite velocity measure averages two distinct motor tasks. High pooled correlations do not establish measurement equivalence or validate a single construct, and separate longitudinal results were not provided. The composite should therefore be regarded as exploratory. Its change cannot substantiate an independent improvement in either jump takeoff velocity or overground sprint velocity.

6. Conclusion

This 12-week intervention demonstrated that both cluster-set configurations were effective in improving maximal strength, muscle power, and movement velocity in recreationally active young adults. The cluster structure with higher repetitions per set (CL1) produced larger improvements in maximal strength, likely due to its greater accumulated mechanical tension. In contrast, the lower-repetition structure (CL2) promoted earlier and consistent gains in power and velocity, reflecting its capacity to preserve movement quality and minimize intra-set fatigue. These findings indicate that cluster sets are a practical and efficient strategy for enhancing neuromuscular performance, and their selection should be aligned with specific training objectives. Coaches and practitioners may also consider alternating both structures across training cycles to optimize long-term adaptations.

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References

Alcaraz, P. E., Carlos-Vivas, J., Oponjuru, B. O., & Martínez-Rodríguez, A. (2018). The effectiveness of resisted sled training for sprint performance: A systematic review and meta-analysis. *Sports Medicine*, *48*(9), 2143–2165. https://doi.org/10.1007/s40279-018-0945-8

American College of Sports Medicine. (2009). Progression models in resistance training for healthy adults. *Medicine & Science in Sports & Exercise*, *41*(3), 687–708. https://doi.org/10.1249/MSS.0b013e3181915670

Arazi, H., Khanmohammadi, A., Asadi, A., & Haff, G. G. (2018). The effect of resistance training set configuration on strength, power, and hormonal adaptation in female volleyball players. *Applied Physiology, Nutrition, and Metabolism*, *43*(2), 154–164. https://doi.org/10.1139/apnm-2017-0478

Asadi, A., & Ramirez-Campillo, R. (2016). Effects of cluster vs. traditional plyometric training sets on maximal-intensity exercise performance. *Medicina*, *52*(1), 41–45. https://doi.org/10.1016/j.medici.2016.01.005

Balsalobre-Fernández, C., Glaister, M., & Lockey, R. A. (2015). The validity and reliability of an iPhone app for measuring vertical jump performance. *Journal of Sports Sciences*, *33*(15), 1574–1579. https://doi.org/10.1080/02640414.2014.996184

Banyard, H. G., Nosaka, K., & Haff, G. G. (2021). Cluster sets: Current knowledge and future directions. *Sports Medicine*, *51*(6), 1137–1150. https://doi.org/10.1007/s40279-020-01438-0

Bentes, C. M., Costa, P. B., Neto, G. R., Costa e Silva, G. V., de Salles, B. F., Miranda, H. L., & Novaes, J. S. (2014). Hypotensive effects and performance responses between different resistance training intensities and exercise orders in apparently healthy women. *Clinical Physiology and Functional Imaging*, *35*(3), 185–190. https://doi.org/10.1111/cpf.12146

Bond, C. W., Willaert, E. M., & Noonan, B. C. (2017). Comparison of three timing systems: Reliability and recommendations for timing short-duration sprints. *Journal of Strength and Conditioning Research*, *31*(4), 1062–1071. https://doi.org/10.1519/JSC.0000000000001560

Brzycki, M. (1993). Strength testing—Predicting a one-rep max from reps-to-fatigue. *Journal of Physical Education, Recreation & Dance*, *64*(1), 88–90.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Routledge Academic.

Cormie, P., McGuigan, M. R., & Newton, R. U. (2011). Developing maximal neuromuscular power: Part 2—Training considerations for improving maximal power production. *Sports Medicine*, *41*(2), 125–146. https://doi.org/10.2165/11538500-000000000-00000

Davies, T. B., Tran, M. K., Hogan, C. A., & Cronin, J. (2023). Long-term effects of cluster set structures on strength and power: A systematic review. *Journal of Strength and Conditioning Research*, *37*(5), 1012–1024. https://doi.org/10.1519/JSC.0000000000004439

Emmonds, S., Nicholson, G., Begg, C., Jones, B., & Bissas, A. (2019). Importance of physical qualities for speed and change of direction ability in elite female soccer players. *Journal of Strength and Conditioning Research*, *33*(6), 1669–1677. https://doi.org/10.1519/JSC.0000000000002044

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1. *Behavior Research Methods*, *41*(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Fernandez-Fernandez, J., Saez de Villarreal, E., Sanz-Rivas, D., & Moya, M. (2016). Effects of 8-week plyometric training on physical performance in young tennis players. *Pediatric Exercise Science*, *28*(1), 77–86. https://doi.org/10.1123/pes.2015-0019

Figueiredo, T., Willardson, J. M., Miranda, H., Bentes, C. M., Reis, V. M., de Salles, B. F., & Simão, R. (2016). Influence of rest interval length between sets on blood pressure and heart rate variability after strength training in prehypertensive men. *Journal of Strength and Conditioning Research*, *30*(7), 1813–1824. https://doi.org/10.1519/JSC.0000000000001274

Gallardo-Fuentes, F., Gallardo-Fuentes, J., Ramirez-Campillo, R., Balsalobre-Fernández, C., Martínez, C., Caniuqueo, A., … Izquierdo, M. (2016). Validity and reliability of MyJump app for measuring jump performance. *Journal of Strength and Conditioning Research*, *30*(7), 2049–2056. https://doi.org/10.1519/JSC.0000000000001282

García-Ramos, A., Feriche, B., & Jaric, S. (2020). Is pneumatic resistance optimal for power training? *Sports Medicine*, *50*(5), 839–852. https://doi.org/10.1007/s40279-019-01245-0

Girman, J. C., Jones, M. T., Matthews, T. D., & Wood, R. J. (2014). Acute effects of a cluster-set protocol on performance and hormonal responses. *European Journal of Sport Science*, *14*(2), 151–159. https://doi.org/10.1080/17461391.2013.785598

Hackett, D. A., Davies, T. B., Ibel, D., Cobley, S., & Sanders, R. (2018). Predictive ability of jump tests for determining strength and power in adolescents. *Measurement in Physical Education and Exercise Science*, *22*(1), 79–87. https://doi.org/10.1080/1091367X.2017.1373551

Haff, G. G., Burgess, S., & Stone, M. H. (2008). Cluster training for strength and conditioning professionals. *UKSCA Journal*, *12*, 12–17.

Harris, R. C., Edwards, R. H., Hultman, E., Nordesjö, L. O., Nylind, B., & Sahlin, K. (1976). Time course of phosphorylcreatine resynthesis during recovery. *Pflügers Archiv*, *367*(2), 137–142. https://doi.org/10.1007/BF00585149

Nickerson, B. S., Mangine, G. T., Williams, T. D., & Martinez, I. A. (2018). Effect of cluster-set warm-ups on sprint performance. *Applied Physiology, Nutrition, and Metabolism*, *43*(6), 625–630. https://doi.org/10.1139/apnm-2017-0525

Nickerson, B. S., Williams, T. D., Snarr, R. L., & Park, K. S. (2019). Inter-repetition rest plus elastic bands on jumping potentiation. *Journal of Strength and Conditioning Research*, *33*(8), 2087–2093. https://doi.org/10.1519/JSC.0000000000002404

Oliver, J. M., Jagim, A. R., Sanchez, A. C., Mardock, M. A., Kelly, K. A., Meredith, H. J., … Kreider, R. B. (2013). Greater gains with intraset rest intervals during hypertrophy training. *Journal of Strength and Conditioning Research*, *27*(11), 3116–3131. https://doi.org/10.1519/JSC.0b013e31828f1dfc

Oliver, J. M., Kreutzer, A., Jenke, S., Phillips, M. D., Mitchell, J. B., & Jones, M. T. (2015). Acute response to cluster sets in trained and untrained men. *European Journal of Applied Physiology*, *115*(11), 2383–2393. https://doi.org/10.1007/s00421-015-3226-2

Randell, A. D., Cronin, J. B., Keogh, J. W., & Gill, N. D. (2010). Transference of strength and power adaptation: Horizontal vs. vertical force production. *Strength and Conditioning Journal*, *32*(4), 100–106. https://doi.org/10.1519/SSC.0b013e3181e93205

Rhea, M. R. (2004). Determining the magnitude of treatment effects in strength training research. *Journal of Strength and Conditioning Research*, *18*(4), 918–920.

Schoenfeld, B. J., Grgic, J., & Van Every, D. W. (2021). The mechanisms of muscular strength gains: A review. *Sports Medicine*, *51*(6), 1351–1367. https://doi.org/10.1007/s40279-021-01449-3

Thomas, J. R., Grimby, G., & Karlsson, J. (1976). Force–velocity relations and muscle fiber composition. *Journal of Applied Physiology*, *40*(1), 12–16. https://doi.org/10.1152/jappl.1976.40.1.12

Thorstensson, A., Grimby, G., & Karlsson, J. (1976). Force–velocity relations and fiber type. *Journal of Applied Physiology*, *40*(1), 12–16.

Tufano, J. J., Brown, L. E., & Haff, G. G. (2017). Theoretical and practical aspects of cluster sets: A systematic review. *Journal of Strength and Conditioning Research*, *31*(3), 848–867. https://doi.org/10.1519/JSC.0000000000001462

Tufano, J. J., Conlon, J. A., Nimphius, S., Oliver, J. M., Kreutzer, A., & Haff, G. G. (2019). Different cluster sets result in similar metabolic and perceptual responses. *Journal of Strength and Conditioning Research*, *33*(2), 346–354. https://doi.org/10.1519/JSC.0000000000002136

Weakley, J., Morrison, M., & Comfort, P. (2020). The effects of cluster sets on power output: A systematic review. *Sports Medicine*, *50*(9), 1569–1582. https://doi.org/10.1007/s40279-020-01292-z

Wilmore, J. H., Costill, D. L., & Kenney, W. L. (2004). *Physiology of sport and exercise* (4th ed.). Human Kinetics.

Figures and Tables

Table 1: Characteristics of the subjects that composed the different study groups.

Variables	Control (n = 10)	p	Cluster 1 (n = 10)	p	Cluster 2 (n = 10)	p
Age (years)	25.40 ± 1.8	0.186	24.00 ± 1.0	0.172	22.60 ± 0.4	0.062
BM (kg)	72.21 ± 3.13	0.083	69.89 ± 3.87	0.565	65.60 ± 4.00	0.444
Height (m)	1.68 ± 0.01	0.170	1.71 ± 0.03	0.329	1.66 ± 0.02	0.408
BMI (kg/cm2)	25.38 ± 0.94	0.299	23.82 ± 0.88	0.121	23.59 ± 0.80	0.552
Time without RT (months)	8.30 ± 1.26	0.175	7.70 ± 1.17	0.170	8.20 ± 0.74	0.161
Experience with RT (months)	20.60 ± 2.17	0.244	17.2 ± 1.08	0.549	19.9 ± 0.9	0.462

BM = Body Mass; BMI = Body Mass Index; RT = Resistance training; Shapiro-Wilk test, to verify the normality of the variables ($p > 0.05$).

Table 2: Pearson correlation values between variables grouped by magnitude.

		Moment			
	Variable	Baseline	Week 4	Week 8	POST
Velocity	V10 x V_S	0.66	0.84	0.81	0.82
	V20 x V_S	0.83	0.83	0.53	0.54
	MV x V_S	0.93	0.91	0.92	0.91
Power	CMJ x CMS	0.64	0.77	0.82	0.77

Note: V10 = Velocity in the first 10-meter of the 20-meter sprint; V20 = Velocity in the final 10-meter of the 20-meter sprint; MV = Mean Velocity of the 20-meter Sprint; Vs = Takeoff output velocity; CMJ = Countermovement jump; CMS = Countermovement sprint.

Table 3: Effect size on the one repetition maximum test, peak power test in the countermovement jump (CMJ) and countermovement Sprint (CMS) exercises and velocity by linear combination of vertical jump and 20-meter sprint tests at different training moments in relation to the baseline.

	Groups	Week 4	Week 8	Post
1-RM	*Control*	0.04 (Trivial)	0.09 (Trivial)	0.09 (Trivial)
	Cluster 1	0.77 (Small)	1.30 (Moderate)	1.77 (Large)
	Cluster 2	0.29 (Trivial)	0.52 (Small)	0.67 (Small)
CMJ	*Control*	0.11 (Trivial)	0.13 (Trivial)	0.09 (Trivial)
	Cluster 1	0.38 (Small)	0.73 (Small)	1.43 (Moderate)
	Cluster 2	0.32 (Trivial)	0.69 (Small)	1.11 (Moderate)
CMS	*Control*	0.24 (Trivial)	0.34 (Trivial)	0.09 (Trivial)
	Cluster 1	0.33 (Trivial)	0.61 (Small)	0.97 (Moderate)
	Cluster 2	0.89 (Moderate)	1.31 (Moderate)	1.21 (Moderate)
VEL	*Control*	0.01 (Trivial)	0.02 (Trivial)	0.17 (Trivial)
	Cluster 1	0.36 (Small)	0.62 (Small)	0.71 (Small)
	Cluster 2	0.32 (Trivial)	0.50 (Small)	0.54 (Small)

Note: 1-RM = One repetition maximum test; CMJ = Countermovement Jump; CMS = Countermovement Sprint; VEL = Velocity.

Figure 1: Experimental design.

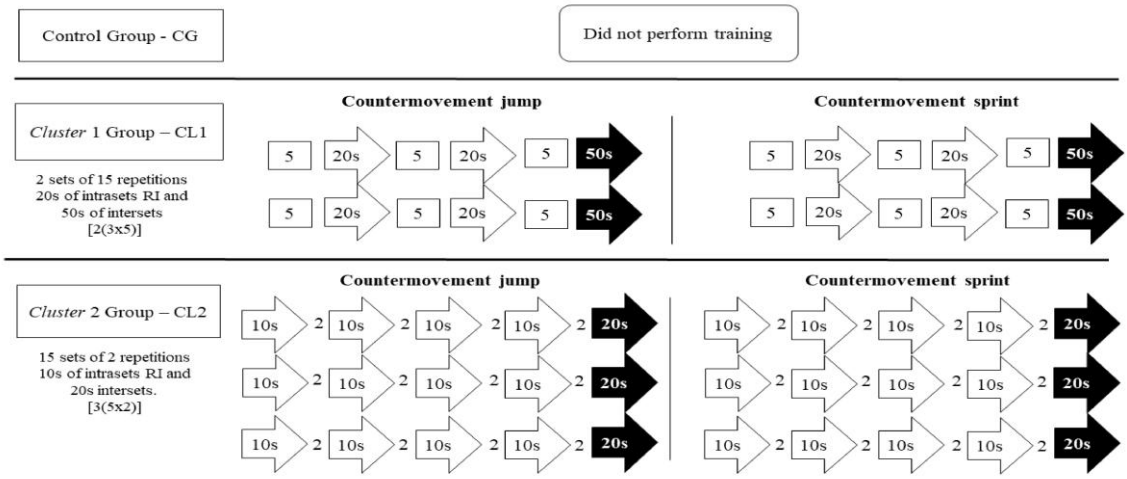


Figure 2: Countermovement jump: initial (2.1.A) and final (2.1.B) position; Countermovement sprint: initial (2.2.A), step back (2.2.B) and final position (2.2.C).

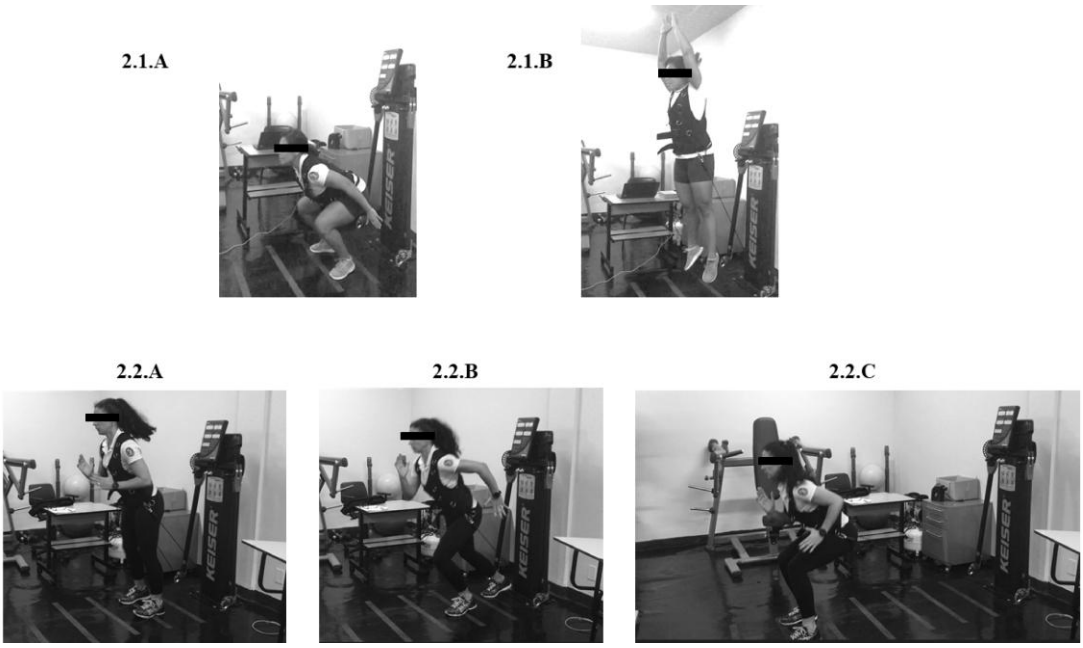
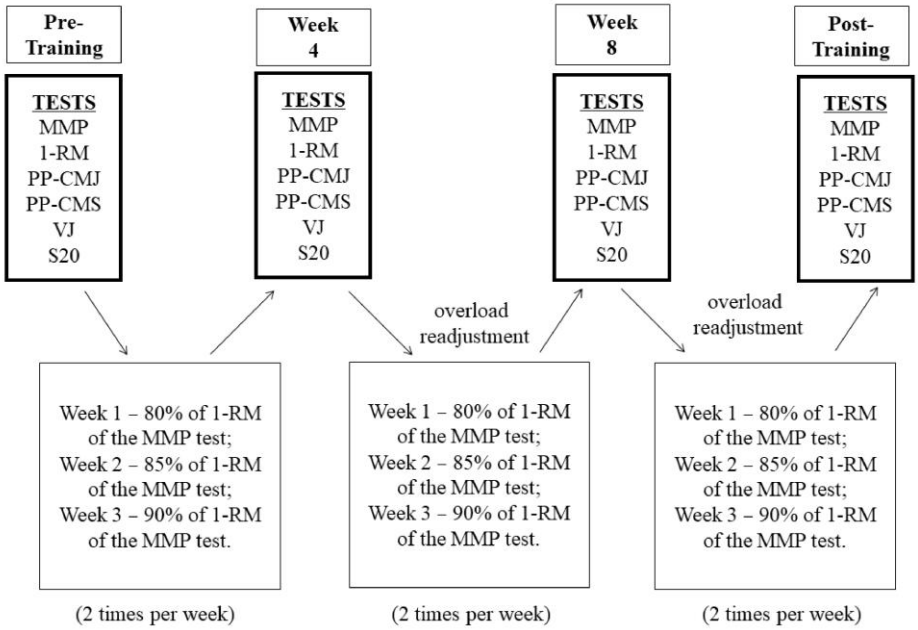
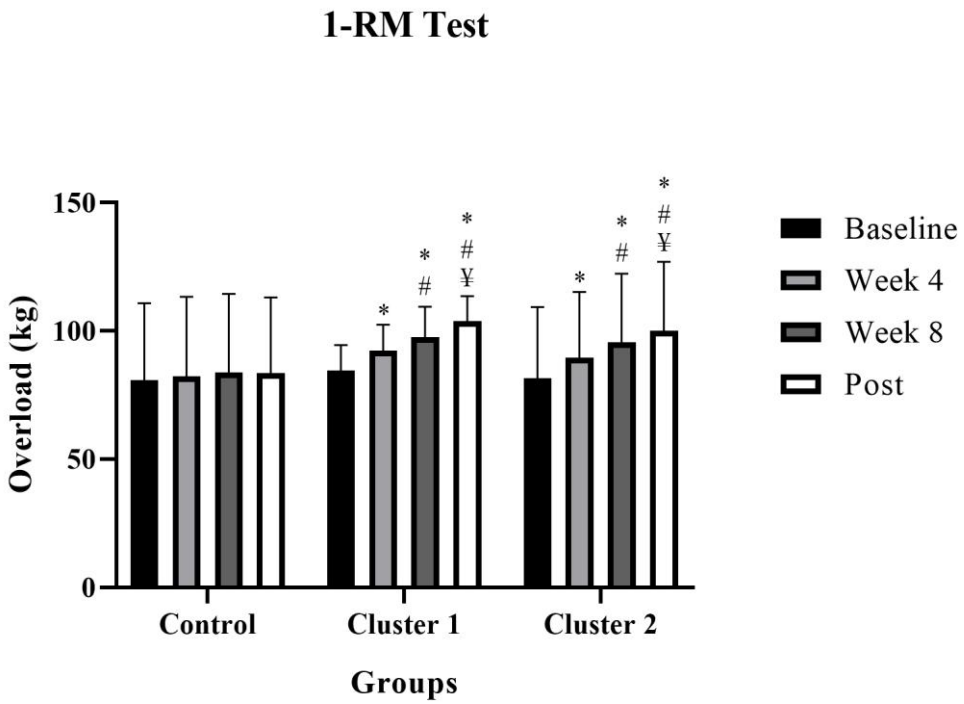


Figure 3: Methodological design of the training on the pneumatic apparatus Keiser.



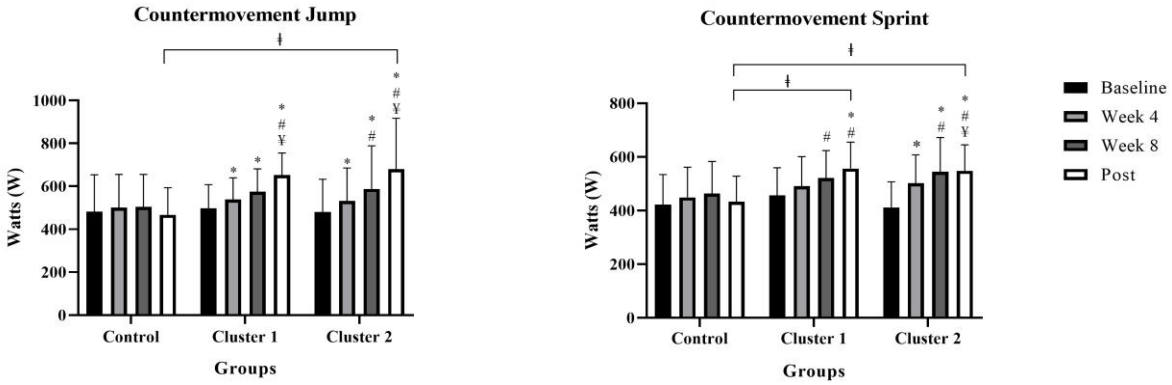
Note: MMP: Maximum muscle power; 1-RM: One repetition maximum test; PP-CMJ: Peak power on countermovement jump; PP-CMS: Peak power on countermovement sprint; VJ: Vertical Jump; S20: 20-meter Sprint.

Figure 4: One maximum repetition test at different training moments.



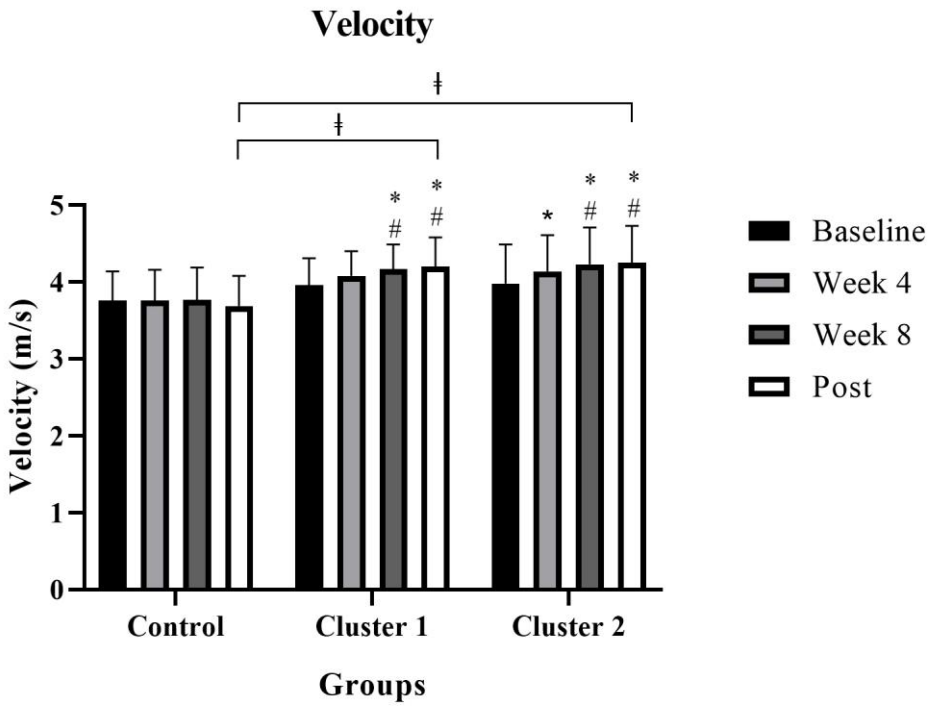
Note. 1-RM: One maximum repetition; *Significant difference for the baseline moment; #Significant difference for the week 4; ¥Significant difference for the week 8.

Figure 5: Maximum muscle power test in countermovement jump and countermovement sprint exercises at different training times.



Note: ǂIntergroup Difference in relation to Control; *Significant difference for the baseline moment; #Significant difference for the week 4; ¥Significant difference for the week 8.

Figure 6: Velocity calculated by linear combination of vertical jump and 20-meter sprint at different training moments.



Note: ǂInter-groups Difference in relation to Control; *Significant difference for the baseline moment; #Significant difference for week 4; ¥Significant difference for week 8.

Declaração Ética

Conflito de Interesse: Nada a declarar. **Financiamento:** Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ), FAPERJ No 32/2021. **Revisão por Pares:** Dupla-cega.

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