Optimal load of resistance training and its acute effects on functional tasks in older adults

La carga óptima del entrenamiento de fuerza y sus efectos agudos sobre las tareas funcionales en adultos mayores

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How to cite in APA

Ruiz Corredor, E. A., Mosquera Martínez, L., Rojas Jaimes, D. A., Rocha dos Santos, P. C., & Barrera Izquierdo, R. A. (2025). Optimal load of resistance training and its acute effects on functional tasks in older adults. *Retos*, *67*, 571–579. https://doi.org/10.47197/retos.v67.114504

Abstract

Introduction: Optimizing strategies to counteract the aging-typical loss of functionality and improve the quality of life is of the utmost importance in life science. Resistance training (RT) may emerge as an important tool targeting functionality in agedness. It is unclear however the role of load in the acute effects of RT on the functionality of senior citizen. Objective: To identify the optimal load of RT and its acute effects on functional tasks in older adults. Methodology: 35 older adults (65-75 years old) voluntarily participated in this study. Repetition maximum (RM) was estimated by dynamic maximal strength via leg extension, leg curl, squat hack, and calves on leg press exercises. Subsequently, once per week, in a random order, participants performed a session of RT with 40%-50%-60%-70%-80%1RM. Functional mobility was assessed via the Time Up and Go (TUG) test at the beginning, immediately after (acute moment), and 20 minutes after (subacute moment) RT. Results: For the acute moment, the percentages of 40% and 50% 1RM showed better performance than the other loads (all p=<0,001), an average of 5,8% and 6,8%, respectively. For the subacute moment, 40% and 50% 1RM indicated better performance when compared with the other loads (all p<0,001), showing an average of 20,76% of better performance with these loads.
Conclusions: Loads of 40%-50% 1RM are optimal to generate acute enhancements in the functional mobility of older adults.

Keywords

Old; Strength training; Intensity; Functionality; Mobility; Physical independence; Physical strain.

Resumen

Introducción: Optimizar las estrategias para contrarrestar la perdida típica de la movilidad asociada al envejecimiento y mejorar la calidad de vida es de suma importancia en las ciencias de la vida. El entrenamiento de fuerza (EF) emerge como una herramienta importante para desarrollar la funcionalidad en la vejez. Sin embargo, se desconoce el rol que tienen las cargas en los efectos agudos del EF sobre la funcionalidad en adultos mayores. Objetivo: Identificar la carga optima del EF y sus efectos agudos sobre la funcionalidad en adultos mayores. Metodología: 35 adultos mayores (65-75 años) participaron voluntariamente en el estudio. Una repetición máxima (1RM) se estimó mediante los ejercicios de extensión de rodilla, flexión de rodilla acostado, sentadilla jaca y pantorrilla en prensa. Una vez por semana de modo aleatorizado, los participantes realizaron una sesión de EF con cargas del 40%-50%-60%-70%-80%1RM. La movilidad funcional fue evaluada mediante la prueba del Time Up and Go (TUG) al inicio, inmediatamente después (momento agudo) y 20 minutos después (momento subagudo) del EF. Resultados: Para el momento agudo los porcentajes del 40% y 50% 1RM arrojaron un mejor rendimiento conforme a las demás cargas (todo p=<0,001), en promedio de 5,8% y 6.8% respectivamente. Para el momento subagudo, el 40% y 50%1RM indicaron mejores tiempos cuando se compara con las demás cargas (todo p<0,001), mostrando un promedio de 20,76% de mejor rendimiento con esas cargas. Conclusiones: Las cargas del 40% y 50% del 1RM son óptimas para generar mejoras agudas en la movilidad funcional en adultos mayores.

Palabras clave

Envejecimiento, entrenamiento de fuerza, intensidad, Funcionalidad, Movilidad, Independencia Física, Tensión Física.

Introduction

Even healthy aging implies a loss of functionality (i.e., capacity to perform basic functional tasks), which has an impact on quality of life, and could generate a conditioning factor for physical dependence (Ferguson, 2014). Lack of functionality is indicated by mobility disability (Virto, 2024), which is a factor that increases the risk of fragility, stumbling, and falls (Jepsen et al., 2022; Palma et al., 2022). It is noteworthy to mention that falls represent approximately 40% of all injury-related deaths and contribute to 20% to 30% mild to severe injuries in this population (Rubenstein, 2006). It is thus reasonable that understanding the age-related impact on mobility is of interest to science and public health agencies (World Health Organization). Functional mobility assessment has been established as a reliable way to infer functionality in clinical and research settings (World health organization, 2007). Among several, the National Institute for Health and Care Excellence (NICE, 2013), has suggested the Timed up and Go (TUG) as a reliable tool to assess balance, gait and identify fall risk (Podsiadlo, D; Richardson, 1991), including the effect of interventions. Besides understanding this, developing intervention strategies to minimize the typical age-related decline in functional mobility is also of utmost importance in minimizing fall risks and improving healthy aging (Jepsen et al., 2022).

Resistance training (RT) has been proven to be a safe and effective intervention for treating and preventing muscle mass and strength loss and improving mobility commonly observed in older adults (Barón et al., 2024; Borde et al., 2015; Mende et al., 2022; Pardo et al., 2024; Peng et al., 2024). Specifically, this type of exercise can improve the efficiency of the neuromuscular system, increase strength, and promote muscle hypertrophy (Evans, 1999; Frontera et al., 1988; Galvão & Taaffe, 2005; Taaffe et al., 1999). For this reason, the National Strength and Conditioning Association (NSCA) recommends emphasizing the inclusion of RT as an integral part of an exercise program for old population (Fragala et al., 2019). Highlighting this statement are the findings of Krops et al., (2018), who indicated that RT optimized physical fitness in people over 85 years of age. In addition, the reported benefits of RT are also related to enhancing mobility and the ability to perform basic tasks such as chair rise (Cadore et al., 2014), which results in an improvement in functionality and physical independence (Lopez et al., 2018). In other words, RT reflects a decrease in functional losses associated with aging.

Of the many dosage variables (training frequency, volume, session, and intervention duration, inter-bout, and inter-session rest), the intensity may be the most critical to ensure exercise effectiveness for old populations (Hortobágyi et al., 2022). Although evidence has assured that both low and high loads are safe to reduce and slow the onset rate of functional losses in healthy elders as long as they are developed with the principles of individualization, progression and periodization (Fragala et al., 2019) and that a slight advantage seems to exist in favor of high vs. low load RT in strength gains (Taaffe et al., 1996; Vincent et al., 2002), there is no consensus on the acute exercise effectiveness in functional mobility in older adults. Opposingly, intensity may also acutely impair mobility performance by reflecting in the accumulation of muscle fatigue (Barahona-Fuentes et al., 2020; Barbieri et al., 2013). Thus, understanding the role of RT intensity (load) in functional mobility is a significant niche very relevant niche for optimizing intervention strategies targeting improving functionality and reducing fall risks in older adults (Bishop et al., 2008; McArdle et al., 2015). Thus, this study aimed to identify the optimal load of RT and its acute effects on functional tasks in neurologically preserved older adults. Based on previous evidence indicating that high vs. low intensity is reflected in slight gains in strength gains (Taaffe et al., 1996; Vincent et al., 2002), our hypothesis is that functional mobility will improve hierarchically with the load increments.

Method

The current research as a longitudinal study using a quasi-experimental design of a quantitative kind.

Participants

Thirty-five healthy older adults (70,23 ± 6,81 years old); body mass (72,58 ± 5,51 Kg), and height (162±5,92 cm) were included in this study. Exclusion criteria were factors that could interfere with gait (such as using assistive devices), medication use, and the presence of neuromuscular, cardiorespiratory, lower limb musculoskeletal diseases, as well as balance and vision disorders. All participants provided their informed consent.

Procedure

Seven days were designed for the experimental protocol. In the first one, the Montreal cognitive assessment (MOCA) cognitive (Hobson, 2015) and Modified Beacke Physical Activity (POLS et al., 1995) were done. In the second session, the baseline (BL) was established in the TUG test, and then the maximum dynamic strength to determine the 1RM test was assessed according to NSCA & Miller, (2012) on the leg extension, leg curl, hack squat machine, and calf press on the leg press machine exercises. For the remaining sessions, participants performed resistance training with 40%, 50%, 60%, 70%, and 80% loads of 1RM once a week. These percentages were randomly assigned for their application to avoid possible adaptations and minimize cumulative effects across sections. Thereby, the protocol during each training session of this study consisted of 4 phases: 1) Warm-up, 2) load application, 3) acute evaluation of functional mobility task, 4) sub-acute evaluation of functional tasks. Hence, the warm-up began with light joint mobility in the lower limb and concluded with cycling for five minutes at a slow pace. Subsequently, participants performed RT according to the raffle of loads for that workday. The RT variables were: 3 sets of 8 -12 repetitions with 40 seconds of rest per set and 3 minutes of rest between exercises. Finally, the evaluation of the functional tasks for each training day consisted of two moments: one acute (once phase two has been completed) and one sub-acute (20 minutes after phase three). The functional mobility task assessment was developed using the TUG test, which involves a patient getting up from a chair from the sitting to the bipedal position, walking three meters, turning, returning, and sitting on the chair again (Podsiadlo, D; Richardson, 1991). It was applied in 5 attempts for each moment. Time (higher time = lower performance) and step numbers taken by the test were the examined variables of interest.

Instrument

- 1RM test was assessed according to the National Strength and Conditioning Association (NSCA).
- The time up and go (TUG) test was done.
- Montreal Cognitive Assessment (MOCA) Cognitive.
- Beacke physical activity questionnaire modified test was established. The results from these tests allowed classification of the participants as neurologically preserved and physically active.

Data analysis

A multivariate analysis of variance (MANOVA) was performed with the factor's "moment" (Bl, Ac, Sac) and load percentages (40%, 50%, 60%, 70%, 80%) 1RM on software IMPM statistic version 27.0. The Bonferroni post hoc test was conducted to identify the statistical differences. The level of significance was set as $p< 0.05$, adjusted for multiple comparisons (Bonferoni method).

Results

In the 1RM protocol, participants indicated (58,34 Kg ± 5.3) for leg extension, (34,59 Kg ± 8.1) leg curl, (89,34Kg ± 9.2) hack squat machine and (65,84 Kg ± 7.4) calf press on the leg press machine exercises.

For both time and steps of TUG, MANOVA indicated the main effects of Moment ($F=3560.7$; $p<0.001$; $\eta p^2=0.98$; and $F=656.988$; $p<0,001$; $\eta p^2=0.89$, respectively) and load percentages ($F=14.13$; $p<0.001$; $\eta p^2=0.26$; and $F=0,53$; $p=0.995$; $\eta p^2=0.01$, respectively) and interaction effects between Moment* load percentages (Wilks' lambda= 0.46; $F=146.34$; $p<0.001$; $\eta p^2=0.79$; Wilks' lambda= 0.26; $F=36.889$; $p<0.001$; $\eta p^2=0.48$, respectively).

For the Bonferroni pairwise comparison, acute moment (AM) vs. baseline (BL) indicated that higher load percentages of 80%, 70%, and 60%1RM acutely and significantly decreased performance on TUG, by ~18%, 13%, and 12% of increases in time (Figure 1), respectively, and 17%, 12% and 12% more steps (Figure 2) in relation to BL (all $p>0.03$). Additionally, while higher load percentages (60-80%RM) resulted in ~12 to 17% decreased TUG performance (time and steps) even in the subacute moment

(SAM) vs. BL (Figures 1 and 2, all p>0.05), lower load intensity (i.e., 40 and 50%1RM) recovered and improved (by 10% and 15%, respectively) the time (not the number of steps) in TUG in the SAM vs. AM and even vs. BL (~9% for 50%1RM) (Figure 1, p>0.05). In contrast, the number of steps increased for all load percentages in the SAM vs. AM for all load percentages (Figure 2, all p>0.05), and mainly for 40 and 50%1RM (~10% and 14%, p>0.03).

Figure 1. Comparison between percentages of 1RM (p1RM) by moment (baseline – BM, acute – AM, and Subacute SAM) of assessment for time variable of TUG. *AM≠BL, #SAM≠AM.
Fuente: Self- employment.

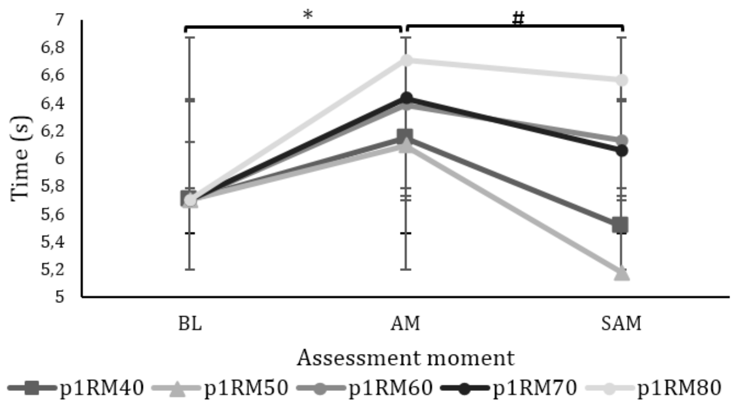
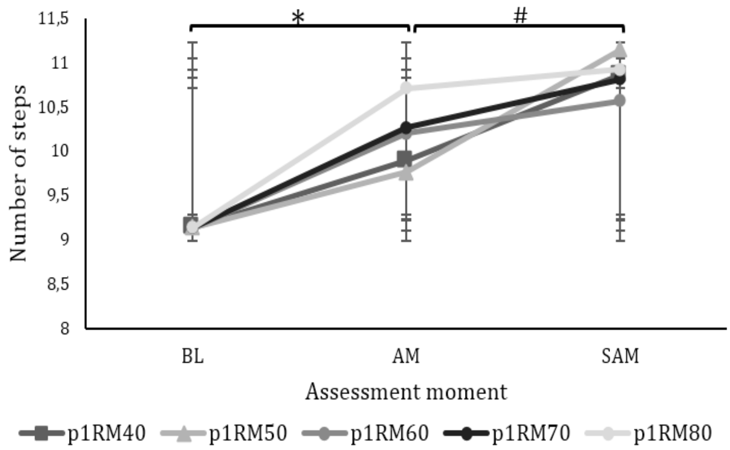


Figure 2. Comparison between percentages of 1RM (1RMp) by moment (baseline – BM, acute – AM, and SubAcute SAM) of assessment for time number of steps of TUG. *AM≠BL, #SAM≠AM.
Fuente: Self-employment.



Discussion

The study aimed to compare the acute and recovery effects of a session of resistance exercise performed at different intensities (40 vs. 50 vs. 60 vs. 70 vs. 80% of RM) on functional mobility (Time and number of steps of TUG). Our primary results showed a hierarchical increase (from 40–80%) in the time required to perform TUG immediately after exercise sessions, with a higher % of RM representing longer times (slower TUG). Additionally, TUG performance recovered after 20 minutes for exercises with lower intensities (40 % and 50%) but not for higher intensities (≥60%). Interestingly, the number of steps increased steadily from baseline to recovery, even with the variation of the time of TUG performance across moments. We interpreted that the exercise-induced changes in functional mobility occurred due to the accumulation of fatigue.

Higher intensities of acute exercises reflected greater changes in TUG time. Our results indicated that performing exercises at intensities higher (≥ 60 %) vs. lower (<60%) of RM reflected a longer TUG time

(Figure 1). These results are counterintuitive, considering that higher vs. lower intensity seems to reflect a slight gain in strength (Taaffe et al., 1996; Vincent et al., 2002). Opposingly, these results may also signify that higher-intensity exercises (even a single session) reflected a higher neuromuscular adaptation (Aagaard et al., 2002; Carroll et al., 2001). Because % of RM is a critical factor to the neuromuscular load, the recruitment of motor units during higher vs. lower is particularly accentuated, reflecting greater muscular damage (Krzysztofik et al., 2019). Additionally, the characteristics of the exercise may be a potential explanation for exercise intensity-induced changes in functional mobility. Herein, the exercise focused on muscular groups (e.g., quadriceps, hamstrings and gastrocnemius) directly involved in TUG tasks such as standing and sitting from a chair (Cezar et al., 2021), walking (Jacquelin Perry, 2010; Neptune & McGowan, 2011), and turning (Hase & Stein, 1999). Thus, intensity-related muscular damage (similar to muscle fatigue) may explain the impairments in TUG as the intensity of the exercise increases.

Reduction in functional mobility performance may be associated with an increase in fatigue. Although fatigue was not directly measured, it is highly likely that exercising at 80% resulted in greater muscle strength reduction, a typical sign of muscle fatigue (Cormie et al., 2011). Since muscle strength reduction and increased fatigue were associated with speed (Mänty et al., 2012), it is reasonable to infer that greater muscle damage due to exercise intensity reflects slower TUG. This argument is supported by evidence indicating that older adults perform functional tasks (such as standing from a chair) with relatively high effort and near their maximal capabilities (Cezar et al., 2021; Hortobágyi et al., 2003). This idea that fatigue impairs functional mobility further agrees with studies indicating that mobility-impaired older adults (including chair rise) also show reduced torque production (Kent-Braun et al., 2014).

Moreover, data from the recovery moment also supports the hypothesis that fatigue was a factor in higher-intensity exercises. While (even not significative) the time of TUG in lower intensity (40 and 50% RM) reduced in 20 minutes of recovery after the exercise session, in higher intensity (60, 70, 80% RM), the performance of TUG remained impaired (Figure 1). Indeed, this seems to be a sign that fatigue was accumulated at higher intensities, agreeing with previous evidence showing that fatigue effects on gait outcomes were not recovered after 20 minutes (Barbieri et al., 2016). Thus, fatigue was likely an intervenient factor in higher- but not lower-intensities exercise.

Interestingly, the number of steps during TUG did not follow the same characteristics over time. A steady increase in steps from baseline to recovery was observed, regardless of the exercise intensity (Figure 2). It indicates that all the differences related to exercise intensity on Time of TUG were mainly determined by the duration of sit-to-stand and stand-to-sit transition and turning phases/segments. Clinically relevant, fatigue's effects affecting critical phases of TUG (transitions and turnings) may be problematic as the chances of accidents during such phases are higher (Granacher et al., 2006; Pai & Bhatt, 2007; Shumway-Cook et al., 2000). Although some literature supports high-intensity exercise (Hortobágyi et al., 2022), caution should be considered when prescribing exercise as it may represent acute fatigue conditions that may persist even after 20 minutes.

This study did have some limitations. The first issue was the lack of direct fatigue measures, such as the velocity loss during a specific task and muscle activity outcomes (e.g., median frequency assessed via electromyography (Cezar et al., 2021), as well as indirect measures, such as perceived exertion scales. Another limitation was identifying only the total time spent on TUG, discriminating against each phase that composes it (turning and transitions). Finally, it would also have been important to perform evaluations with longer recovery periods, for example, one hour after having applied the RT.

Conclusions

The results of this study strengthen the idea that high intensities of RT can increase the probability of generating greater fatigue, which negatively impacts the functionality of older adults in both acute and subacute periods. On the other hand, light / lower intensity loads (40%1RM and 50%1RM) promote functional improvement in mobility in this population by decreasing the total TUG time spent, evidencing better effects 20 minutes after performing the RT. Thus, it can be concluded that the lower loads (40%1RM and 50%1RM) of RT are optimal for generating acute functional enhancements in mobility in older adults.

Financing

This research was financed for committed of research for the University of Llanos (Colombia). PCRS was supported by IDOR/Pioneer Science Initiative [PCRS (www.pioneerscience.org)]. Funding agencies did not influence the content of the manuscript.

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