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Original Article

Short term power exercises increase physical fitness in middle aged adults.

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Abstract
The aging process starts around middle age, from all losses that are natural to the process the loss of muscle power is an important one. It happens in part from the nervous system impairments and in part from the muscle mass loss. This problem can be solved with the right kind of exercise. Objective, The objective of this study was to determine the effects of short term power exercises in a middle aged group. Methods, Twenty two healthy subjects from both genders were divided in two groups YG (up to 35) and MAG (up to 65). There were 8 sessions of exercise of 10 minutes each. Exercises were set in two different circuits with 5 exercises and 4 rounds of each that lasted 20 seconds of exercise with 10 seconds of rest. Subjects were oriented to do the exercise as fasts as they could and the exercises were simple and base on ADLs. We evaluated body composition, muscle and anaerobic power and total work produced, RPE and lactate of the training sessions. Results, although there were no differences between the groups, MAG showed similar improvements as YG for all variables measured. Conclusion, We can conclude that short term intense power exercises result in physical fitness improvements even with few and short sessions.
Key words: High intensity exercises; Middle age; Physical fitness.

Introduction

Functional physical capacities are described, among others, as muscle resistance, agility, balance, flexibility, motor coordination, strength and speed in a classical article [1].

These capacities reach their peak between the age of 20 or 30 years, with a plateau around the age of 40, when the beginning of the aging process starts [2]. From these capacities, strength and speed are between the most studied in the literature, with the sum of them, muscle power, being among the ones who present an important age related functional decrease [3]. Due to the decline of these capacities, some morphological changes also can be noted, starting in the middle age and becoming more marked in the elderly, regarding mainly muscle mass. These changes promote a loss of muscle volume of approximately 30%. Lower limbs are the most affected, with a reduction of 20%, mainly in the medium third of the thigh, analyzed in a cross section view. The end result of this progressive and natural loss observed during the aging process is called Sarcopenia [4]. The European Sarcopenia Consensus, [5] first defined Sarcopenia as a physiological process of muscle mass loss. The main factors that lead to Sarcopenia are hormonal decreases, metabolic and immunologic alterations, associated to structural changes in the muscle fibers that aggravates when is combined with physical inactivity.

Dynapenia is also a phenomenon that is age related. It is regarded as a loss of muscle power with several components involved, among them the loss of muscle mass, motor unit firing rates and selective decrease in the number and size of type II muscle fibers [6]. Due to the muscle mass loss and metabolic rate decrease, the aging individual present an increase in the fat depot, most of the times visible in the beginning of the aging process, causing this individual to be more unstable which latter might lead to changes in the gait, especially in older subjects. That is a concern since it's directly associated with falls and all the problems that come from it [7]. This process is marked in the elderly, but small changes that lead to all the consequences above start much earlier and although it is a visible and predictable process, little attention is given to it, with the consequences being almost a certain future from a slightly unbalanced middle age.

The aging process becomes more intense over 60 years of age [8], but there are losses of muscle mass reported between 30 and 50% between 30 and 80 years. Cardiorespiratory fitness also declines in a non linear manner and it accelerates its pace after 45 years, a lot earlier then old age as defined by the World health organization [9]. Another interesting study that adds the social issue to the topic is the study, reports that in middle aged women intense signs of muscle and function losses in the lower limbs can be noted as soon as 50 years, and that is associated with little exercise due to a busy lifestyle [10].

One well described strategy used to counteract the deleterious consequences of the aging process, at any time point, is exercise. One study [11] conducted for 4 weeks with low volume high intensity exercises showed

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similar cardiorespiratory improvements for the middle aged group when compared to the young group. It is also stated that older adults who engage in greater amounts of physical activity have more favorable body composition and greater muscle strength when compared to sedentary individuals [12].

However, most of the exercise studies conducted with the middle age or aging population is either with strength exercises or endurance exercises [13], probably because of its safety concerns, the same article still states that there are very few studies with power or high intensity exercise to this population. Interestingly this is a kind of exercise that could affect most of the changes that happen in the aging process.

An active lifestyle is associated with the well succeeded aging process. The American College of Sports Medicine states [14] that 150 minutes of weekly moderate exercise means healthy benefits that can help in the aging process. That recommendation is associated with longer periods, as the term lifestyle denotes. However, there is no information in the literature about the least amount needed to generate benefits. Another question that remains is if there is a relationship between the type of exercise and the resulting benefits?

So, the objective of this study was to evaluate the effects of high intensity exercise on physical fitness aspects of aging adults.

Methods

All subjects read and signed an informed consent form, and all experimental procedures were approved by the Research Ethical Committee of the São Judas Tadeu University, under the protocol number of CAAE 18504513.8.0000.0089. Subjects also presented a medical certificate that would verify their ability to perform physical activities.

Experimental groups

22 subjects of both genders were divided in two experimental groups. The Young group (YG) was composed of subjects of 30 to 35 years old, which represents the peak of functional capacity. The Midle age group (MAG) was composed of subjects from 35 to 65 years old, (average age 45.55 years) which we considered a representative sample of the beginning of the aging process. In a group with this age, most of the initial signs of the aging process such as metabolic rate decrease with negative changes in body composition and muscle power and agility losses are already present.

Inclusion and exclusion criteria

All subjects included could come to the university in the day and time of the training sessions and had a medical consent to exercise. Subjects with labyrinthitis, uncontrolled blood pressure higher than 180mmHg, substantial joint instability (i.e. non treated rupture of the anterior cruciat ligament) and non treated muscle injuries were considered excluded from the study. After the beginning of the protocol, subjects that missed 3 consecutive sessions were also excluded.

Evaluation moments and Variables analyzed

All subjects were analyzed twice, in the Initial (I) moment and in the Final (F) moment, for the following variables: body fat %, Anaerobic power (Wingate), total work produced (maximum number of repetition) and muscular power (Isokinetic test).

Some evaluations were carried everyday during the protocol, before (Pre) and after (Post) the exercise session, such as RPE from the BORG scale, the total number of maximum repetitions done in each exercise station (in each of the 4 times that the subject would be in that station) and blood lactate concentration that was analyzed Pre Training and Post Training in one exercise session of each circuit, in both moments, I and F.

Body composition evaluation

The following areas were measured: chest, waist, hips, abdominal, thighs, arms and forearms and both legs.

For the body fat percentage (%F), fat mass (FM) and muscle mass (MM) measurement we used Jackson and Pollock 7-site skinfold protocol (Tricep + Subscapular + Suprailiac + Abdominal + Axilla + Chest + thigh) [15], to do the calculations we used the Physical test 7.0 physical evaluation program.

Wingate power test

Wingate Power test consisted of 30 seconds of maximum relative intensity. It was carried out in a special bicycle with 4% of the subject total weight as load. We used the test results of max power (Wmax), average power (Wavg), min power (Wmin) and fatigue index (%F) [16,17].

Isocinetic evaluation

Isocinetic evaluation was carried out so we could measure muscular power production in a sophisticated equipment that allows us to understand how the different muscle fibers work in different situations as we tested 3 velocities.

Subjects were placed in the dynamometer's chair in a position where they were at 90^{o} of hip flexion, they were stabilized with contention belts crossed over the trunk, hips and dominant leg thigh.

The dynamometer mechanical axle was aligned with the femur lateral condyle and the leg was attached to the resistance arm of the equipment, with free joint movement.

The isokinetic equipment (Biodex Medical System 3, Manual Applications / Operations, 2013) was set to the following protocol: 5 repetitions on low speed (60º/s), 10 repetitions on medium speed (180º/s) and 10 repetitions on high speed (300º/s), with a 2 minutes interval between the sets [18, 19]. Subjects were verbally stimulated as well as they saw the visual stimuli at the monitor throughout the entire protocol.

Total number of repetition

Subjects were instructed to do the maximum number of repetition possible, in their own pace, in each exercise, the load of the exercises would be either their own weight or a very light weight (as described below).

The total number of repetition was added and divided by the total time that subjects were active. This time was calculated using this values: total training time 10 min. or 600 seconds, total active time 400 seconds, rest or inactive time 200 seconds. This calculation returned a repetition per second value (rep/sec) showed in the results section.

RPE measured by the modified BORG scale

The modified BORG [20] scale is an adaptation from the original BORG scale, it goes from 0-10, being 0 the lower effort level and 10 the highest effort level, being easier to the subject to refer to a value. RPE was collected from all exercises in every one of the four rounds. We calculated the average of each round from the first session (I) and from the last session (F).

Blood lactate concentration

Pre training and Post training of one session of exercise, we measured blood lactate concentration, from a drop of blood in an Accutrend lactate equipment (Roche). That measurement was done both in the I and F moments of the training protocol.

Training protocol

Training had a total duration of 7 weeks divided in 3 periods:

1 º – Adaptation and identification period,

2º - Physical evaluation period: We did the Isokinetic and Wingate tests, within one or two weeks after the identification period, in order to avoid that the subjects would start the tests with no previous knowledge of the activity.

3º - Actual training period. The training protocol, described below, was according to the Tabata method [21].

1 º Adaptation and identification period

This period was 1 week long and the subjects did 2 training sessions. Subjects were instructed about the type of exercises that would compose the circuit protocol and how to perform them.

They were also instructed on how to use the Borg modified scale (0-10), with the purpose of identifying the Rate of Perceived Exertion (RPE) [20].

3º Actual training period

Training protocol was done twice a week for 4 weeks in a circuit training model, with a total of 8 sessions.

Subjects would do a 5 minute walk warm up and would do the first circuit (C1) in a day and the second circuit (C2) in another day.

Circuits were organized as 5 stations/exercises with a total of 4 rounds through them. In each station, there was 20 seconds of individualized maximum speed execution of the movement with a 10 seconds interval that was used to move to the other exercise station. At the end of each station, subjects were required to grade the RPE according to the modified Borg scale as well as the number of repetitions done within the 20 seconds in that station (recorded by a member of the research team in a specific sheet). This process was the same to C1 or C2, with different exercises. Total training session time was 10 minutes.

Training circuit exercises

C1 was composed of:

1 – Abdominal 45º, 2 – Push ups (knee push ups were allowed), 3 – Free squats (no weight); 4 – Biceps curls (3 kg dumbbell) and 5 – 20 meters run.

C2 was composed of:

1 – Climbing up and down 2 stair cases, 2 – Bent rows (3 kg dumbbell), 3 – Free lunges (no weight); 4 – French triceps curls (3 kg dumbbell) and 5 – Lower abdominal exercises.

Exercises were chosen based on ADLs and IADLs, functionality and agility.

Statistical analysis

After the confirmation of normality with a Kolmogorov-Smirnov test, we carried out a ANOVA one way for between groups and repeated measures for within groups comparison. When needed we used repeated measures T test for within group and independent T test for between groups further analysis. We used the SPSS program, version 20.0. Significance was set to $p<0.05$.

Results

22 subjects participated in the study, being divided in 2 groups, YG (n=11) and MAG (n=11). There was no difference between both groups for the parameters presented below. (table 1)

Table 1 – Lifestyle data from both groups, results are mean ± standard deviation or percentage.

	Age	Physical Activity		Smoke		Alcohol		Food consump.	
		Yes	No	Yes	No	Yes	No	Yes	No
YG (n=11)	30.09±1.81	54.50%	45.45%	9.09%	90.91%	27.27%	72.73%	45.50%	55.00%
MAG (n=11)	45.55±9.80	63.64%	36.36%	9.09%	90.91%	36.40%	63.60%	55.00%	45.50%

A significant decrease in fat mass and a significant increase in muscle mass for both groups, were observed, in the F moment compared to I moment. However, only the MAG group showed a significant decrease in body fat %, in the F moment, compared to I moment. Even with this isolated result, there was no difference between the groups (table 2). Total work produced was calculated by the number of repetitions divided by the time of execution (20 seconds) generating the result in repetitions per second (reps/sec). We observed that both groups increased the number of total repetitions in the end of the protocol, data was compared between the initial and final moments (table 2). Borg adapted scale was used throughout the training protocol and lactate concentration was measured PRE and POST of I and F moments, both to assess the training intensity. Borg adapted scale showed lower values for the first rounds becoming statistically higher during the execution of the circuit. There was no difference for the values for the initial rounds and final rounds when we compare the Initial and the final moments (table 2).Lactate values were always statistically higher for the POST moments of the training sessions compared to the PRE values. There was no difference between initial or final values during the training period or when the different groups were compared (table 2).

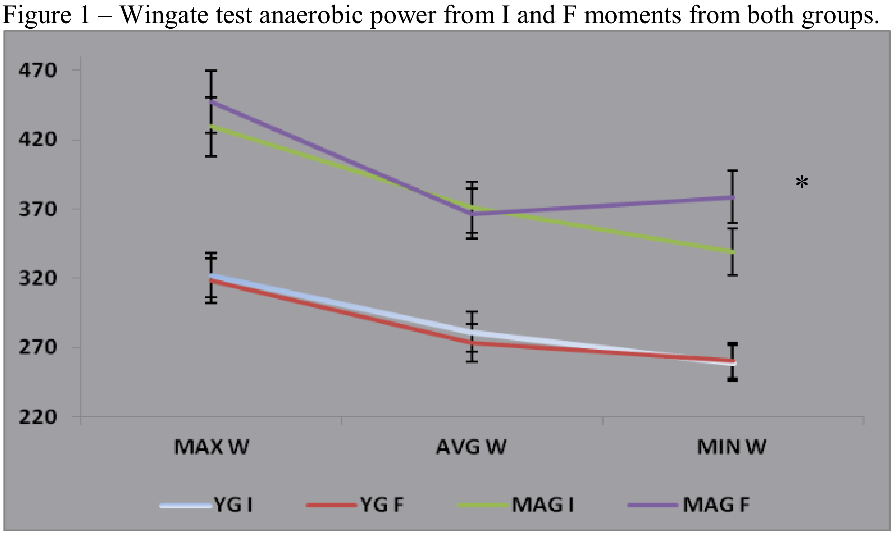
Table 2. Fat percentage (%F), Number of repetitions, RPE and blood Lactate concentration (mmol/L), results are mean ± standard deviation.

	YG		MAG		
	Initial	Final	Initial	Final	p value (YG;MAG)
Body Fat (%)	25.70±6.29	23.68±5.93*	25.73±7.67	23.4±7.08*	0.001; 0.00015
Number of Repetitions (reps/sec)	0.68±0.16(C1) 0.87±0.16(C2)	0.78±0.11(C1)* 1.03±0.13(C2)*	0.72±0.21(C1) 0.95±0.17(C2)	0.87±0.17(C1)* 1.12±0.23(C2)*	0.002;0.004 0.003;0.002
RPE (Borg scale)[a]	7.82±1.82	7.92±1.22	6,36±1.35	7.20±1.92	
Blood lactate (mmol/L)	1.98±0.53(pre) 10.53±1.15(post)#	1.73±0.56(pre) 11.71±2.86(post)#	2.07±0.9(pre) 12.79±2.09(post)#	1.71±0.45(pre) 13.12±3.46(post)#	3.25(e^{-7}) 6.74(e^{-9}) 0.001 5.57(e^{-7})

*p<0.05 compared to Initial. #p<0.05 compared to pre. [a] rate of perceived exertion registered immediately in the end of the exercise session. $3.25e^{-7}$=0.000000325; $6.74e^{-9}$= 0.00000000674; $5.57e^{-7}$= 0.000000557.

Wingate evaluation generated the following itens, Max Power (Max W), average Power (Avg W), minimum power (Min W) and fatigue percentage. We observed that YG showed a linear decrease for Max W, Avg W and Min W, when we compare I and F moments. Meanwhile, MAG presented a steeper decrease from Max W to Avg W (not statistically significant) when compared to YG. However, this group presented a significant interesting increase from Avg W to Min W only in the final moment (Figure 1).

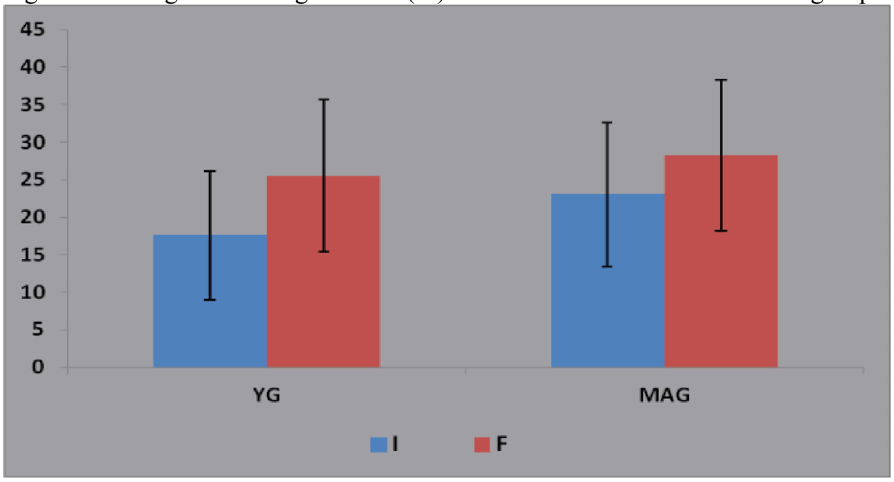
Figure 1 – Wingate test anaerobic power from I and F moments from both groups.



* p<0.05 when compared to AVG W.

When we observe the fatigue percentage, only MAG presented a significant increase (Figure 2).

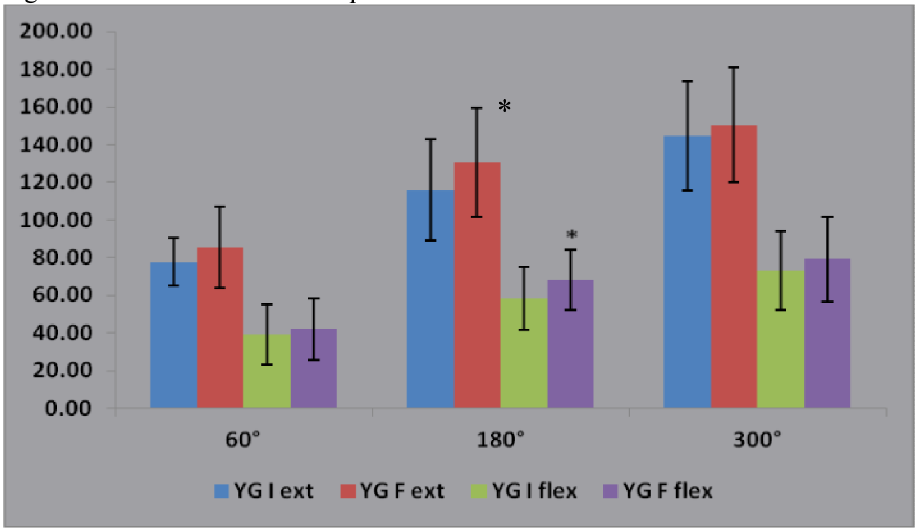
Figure 2 – Wingate test fatigue index (%) from I and F moments from both groups.



In the muscle power variable, evaluated by the isokinetic test, YG showed higher values for the 180 º speed, in the knee extension and flexion movement, when we compare initial and final moments. All other values for power, for this group, showed no differences (figure 3).

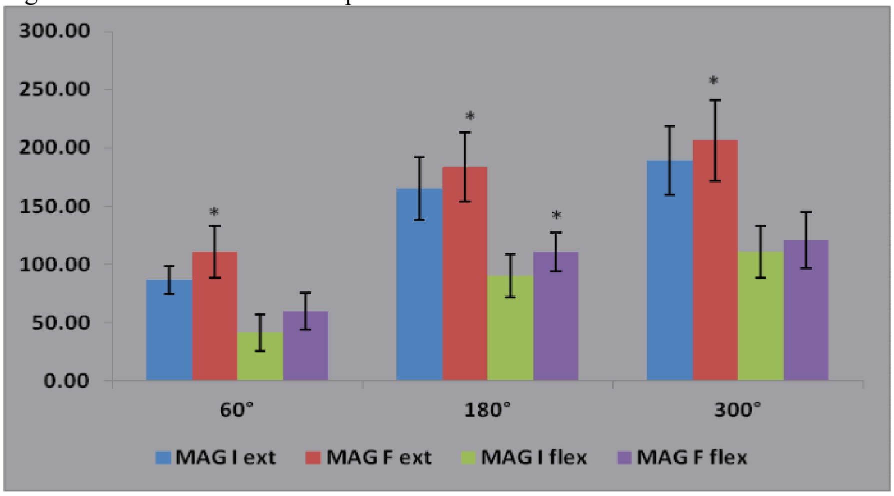
MAG showed statistically higher values for muscle power in all speeds (60º, 180 º and 300º) for the knee extension movement, and only for the 180 º speed in the flexion movement, when we compare initial and final moments (figure 4).

Figure 3 – Power values for all speeds in the extension and flexion movements for the Young group.



* p<0.05 when compared to I for both ext and flex.

Figure 4 - Power values for all speeds in the extension and flexion movements for the MAG group.



* p<0.05 compared to I values for both ext and flex.

Discussion

The main findings of this study were the increased physical capacity and the decrease in body of fat of the subjects trained for 4 weeks only. We believe that this result is due to the type of training used in our experimental protocol. Although these results were possible for the YG the MAG showed surprising results, such as the significant reduction in body fat, reminding that both groups had active and sedentary participants distributed equally.

There are studies with 8 weeks of training length, as described in a meta analysis [22], but none of them used Tabata's method [21] (in our study we used 4 rounds with 5 exercises, with a total of 10 minutes per session, 2 x a week) in the end, our protocol resulted in 20 minutes of exercise per week or a total of 80 minutes in 4 weeks, which is much less than any other protocol described in the literature.

One study published showed no differences in a 4 week study when a young group was compared to an older group (40-50 years), using interval training [11]. The study showed improvements for both groups in aerobic and anaerobic parameters.

Several studies in the literature show how muscle is affected by the aging process and all the consequences of it for middle age and older age subjects [10, 23, 24, 7]. The same can be found on the type of exercise that can be used to mitigate these losses [11, 25, 3]. However, especially for the older subjects, just a few studies can be found using power exercise [26, 24, 23]. That is comprehensible because of the risk involved in this kind of strategy, even when we consider using these exercises with middle age subjects. However, we considered that with the proper safety measures (i.e. relative maximum intensity, lighter load when added speed and supervised exercise for instance) it becomes a unique strategy that can promote some adaptation that other strategies would either fail to promote or need more time to do it.

Our training monitoring parameters such as perceived exertion through the Borg scale, blood lactate concentration and the total amount of work, measured by the total number of repetition done in each session of 10 minutes of exercise were all correspondent to the high intensity planned. The total number of repetition indicates that the MAG was able to increase the amount of work produced during the training protocol, we didn't analyze the technique or the speed of the movement but we oriented them to perform complete movements and there was always somebody from our staff to take note of the amount performed and to prevent them from counting it wrong.

Other studies evaluated high intensity training in the elderly, and they found corresponding levels of perceived exertion (PE) to the ones we found in our study. PE levels on two different strategies of high intensity exercise (hypertrophy training and high speed circuit training) vary from 5 to 7 (on an adapted Borg Scale from 0 to 10) [23]. Another study where the elderly did high intensity (70% of 1 RM) training for lower limbs power gain for 16 weeks maintained a level of PE between somewhat hard and hard (13 to 14) [27].

Subjects were asked to do the exercises as fast as they could, pushing up to their individual limits, and as that is self adjustable, they could keep the high intensity and we could record that throughout the entire exercise protocol.

The Wingate tests showed us some interesting results, with no differences for the YG, the MAG showed a typical graph for the initial test with the produced power falling during the 30 seconds sprint, but the last MAG group test showed a significant increase in the minimum power generated when compared to the initial test. With no different stimulation (other than verbal stimuli identical to the first test), or any important differences subjects weight or muscle mass, we believe that our result suggests an improvement in the capacity of muscle voluntary activation. As we understand that one of the first changes promoted by exercise training is the neural adaptation that can be seen as the capacity of muscle voluntary activation. This voluntary neuromuscular activation is an important feature that declines with aging and precedes the loss of functionality [28]. On the other hand 16 weeks of low resistance but high speed power training promoted significant increases in neuromuscular activation [27], as our protocol was short but with a high intensity power demand, we believe it elicited such response. There were improvements both in 60 and 180°/sec for extension and flexion for both groups. Although that was expected for the YG, due to the intensity of the exercises, the MAG probably had more functional benefits from that result. Since we used a short term strategy, we believe that this increase was, at least in part, a consequence of the muscle voluntary activation [29]. Dynapenia is a term that defines the age related loss of muscle power [30]. That term comprises several elements that contribute to the muscle power generation. Clearly the type of fiber used and the activation of these fibers are important elements.

The different contribution of the fiber type in the isokinetic test is described in a classic book that shows that slow velocities have the participation of slow and fast twitch muscle fibers and fast velocities have the fast twitch fibers only when it comes to torque production [31].

With that concept, it is believed that the relative decrease in peak torque (PT) and/or increase in mean power (MP) from slow to fast speeds in the isokinetic test could be used as indicators of dynapenia, reflecting the age-related changes in type II muscle fiber number, size, or function [6].

We observed an additional increase in the MAG in the 300°/sec velocity, only for the extension movement and that result is consistent with the increase in miminum power produced by this group. Since

300°/sec is considered a velocity that demands muscle power and we have other result that adds to this, we can state that the MAG, in the end of the protocol, was able to produce more muscle power than in the beginning.

The main composition of the training strategy was muscle power. As already said, that is one of the first features which decline with age. When you consider that, with age spontaneous activities that involves power tends to decrease significantly, even few short term sessions that stimulate that capacity, as our results pointed out, produce good results.

Conclusion

We can conclude that short term intense power exercises, might be done safely and result in physical fitness improvements even with few and short sessions.

Far from being the only or best exercise technique to improve fitness in the Middle age, we also believe that, due to its features, this kind of exercise might improve adherence and therefore be of some importance especially to those who use time or motivation as excuses not to exercise.

Conflict of interests

The authors declare that there is no conflict of interests.

References

Caspersen CJ, Powell KE (1985) Christenson GM Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep 100(2):126-31.

World Health Organization (2007) Global Report on Falls Prevention in Older Age http://www.who.int/ageing/publications/Falls_prevention7March.pdf. Acessed 02 February 2014.

Cadore EL, Izquierdo M (2013) How to simultaneously optimize muscle strength, power, functional capacity, and cardiovascular gains in the elderly: an update. Age (Dordr) 35(6):2329-44. doi:10.1007/s11357-012-9503-x

Montero-Fernández N, Serra-Rexach JA (2013) Role of Exercise on Sarcopenia in the Elderly. Eur J Phys Rehabil Med 49:131-134.

Cruz-Jentoft AJ et al (2010) European Working Group on Sarcopenia in Older People. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing 39(4):412-23. doi: 10.1093/ageing/afq034.

Jenkins ND, Housh TJ, Palmer TB, Cochrane KC, Bergstrom HC, Johnson GO, Schmidt RJ, Cramer JT (2015) Relative differences in strength and power from slow to fast isokinetic velocities may reflect dynapenia. Muscle Nerve 52(1):120-30. doi: 10.1002/mus.24505.

Trombetti A, Reid KF, Hars M, Herrmann FR, Pasha E, Phillips EM, Fielding RA (2015) Age-associated declines in muscle mass, strength, power, and physical performance: impact on fear o falling and quality of life. Osteoporos 21.

Milanović Z, Pantelić S, Trajković N, Sporiš G, Kostić R, James N. Age-related decrease in physical activity and functional fitness among elderly men and women. Clin Interv Aging. 2013;8:549-56. doi: 10.2147/CIA.S44112. Epub 2013 May 21.

Jackson AS, Sui X, Hébert JR, Church TS, Blair SN.Role of lifestyle and aging on the longitudinal change in cardiorespiratory fitness.Arch Intern Med. 2009 Oct 26;169(19):1781-7. doi: 10.1001/archinternmed.2009.312.

Lee YS, Chang LY, Chung WH, Lin TC, Shiang TY. Does functional fitness decline in accordance with our expectation? - a pilot study in healthy female. BMC Sports Sci Med Rehabil. 2015 Jul 10;7:17. doi: 10.1186/s13102-015-0012-y. eCollection 2015.

Chastin SF, Ferriolli E, Stephens NA, Fearon KC, Greig C (2012) Relationship between sedentary behaviour, physical activity, muscle quality and body composition in healthy older adults. Age Ageing 41(1):111-4. doi: 10.1093/ageing/afr075.

Willoughby TN, Thomas MP, Schmale MS, Copeland JL, Hazell TJ. Four weeks of running sprint interval training improves cardiorespiratory fitness inyoung and middle-aged adults. J Sports Sci. 2015 Oct 30:1-8. [Epub ahead of print]

Zocoler CAS, Buriti M A, Witter C, Rodrigues B, Pereira E S, Caperuto E C (2014) Análise dos treinamentos físicos aplicados em idosos: revisão da produção científica. EFDeportes.com, Revista Digital 19(197).

Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, Nieman DC, Swain DP (2011) American College of Sports Medicine position stand: Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc 43(7):1334-59. doi: 10.1249/MSS.0b013e318213fefb.

Jackson AS, Pollock ML (1985) Practical assessment of body composition. Phys Sportsmed 13:76–90

Queirosa MR et al (2013) Validity of the RAST for Evaluating anaerobic power performance as compared to wingate test in cycling athletes. Motriz: rev. educ. fis. 19(4).

Franco BL et al (2012) Acute Effects of Three Different Stretching Protocols on the Wingate Test Performance. Journal of Sports Science and Medicine 11:1-7.

Boyle M. Evidence-based Clinical Protocols: 3-Anterior Cruciate Ligament Injury & Reconstruction. http://www.biodex.com/sites/default/files/900521anterior.pdf. Acessed 18 october 2015.

Alexandre PF et al (2009) Análise Comparativa do Desempenho Muscular Isocinético entre

JMAGadores de Futebol. Universidade Católica de Brasília. Educação física em Revista 3(2):1-12.

Borg GAV (1982) Psychophysical bases of perceived exertion. MSSE 14(5):377-381.

Tabata I. et al (1997) Metabolic Profile of High Intensity Intermitente Exercises. MedSci Sports Exerc, 29(3) Disponível em http://gateway.tx.ovid.com/gw1/ovidweb.cgi, Acessed 20 April 2013.

Borde R, Hortobágyi T, Granacher U (2015) Dose-Response Relationships of Resistance Training in Healthy Old Adults: A Systematic Review and Meta-Analysis. Sports Med 5.

Balachandran A, Krawczyk SN, Potiaumpai M, Signorile JF (2014) High-speed circuit training vs hypertrophy training to improve physical function insarcopenic obese adults: a randomized controlled trial. Exp Gerontol 60:64-71. doi: 10.1016/j.exger.2014.09.016.

Valls MR, Dimauro I, Brunelli A, Tranchita E, Ciminelli E, Caserotti P, Duranti G, Sabatini S, Parisi P, Parisi A,Caporossi D (2014) Explosive type of moderate-resistance training induces functional, cardiovascular, and molecular adaptations in the elderly. Age 36:759-72. doi:

10.1007/s11357-013-9584-1. Epub 2013 Oct 18.

Weston M, Taylor KL, Batterham AM, Hopkins WG. Effects of low-volume high-intensity interval training (HIT) on fitness in adults: a meta-analysis of controlled and non-controlled trials. Sports Med. 2014 Jul;44(7):1005-17. doi: 10.1007/s40279-014-0180-z.

Miszko TA, Cress ME, Slade JM, Covey CJ, Agrawal SK, Doerr CE. Effect of strength and power training on physical function in community-dwelling older adults. Gerontol A Biol Med Sci . 2003 Feb;58(2):171-5.

Reid KF, Martin KI, Doros G, Clark DJ, Hau C, Patten C, Phillips EM, Frontera WR, Fielding RA (2014) Comparative effects of light or heavy resistance power training for improving lower extremity power and physical performance in mobility-limited older adults. J Gerontol A Biol Sci Med Sci 70(3):374-80. doi: 10.1093/gerona/glu156.

Clark DJ, Manini TM, Fielding RA, Patten C (2013) Neuromuscular determinants of maximum walking speed in well-functioning older adults. Exp Gerontol 48(3):358-63 doi:10.1016/j.exger.2013.01.010.

Clark DJ, Reid KF, Patten C, Phillips EM, Ring SA, Wu SS,Fielding RA (2014) Does quadriceps neuromuscular activation capability explain walking speed in older men and women? Exp Gerontol. 55:49-53. doi: 10.1016/j.exger.2014.03.019.

Clark BC, Manini TM (2008) Sarcopenia =/= dynapenia. J Gerontol A Biol Sci Med Sci.63(8):829-34.

Faulkner JA, Claflin DR, McCully KK (1986) Power output of fast and slow fibers from human skeletal muscles. In: Jones NL, McCartney N, McComas AJ (ed) Human Muscle Power. Human Kinetics Publishers Inc, Champaig,. pp 81-94.