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Effects of concurrent training with self-selected intensity on the physical fitness of hypertensive individuals

Silas Nery de Oliveira[1*], Antônio Renato Pereira Moro[1], Wagner Jorge Ribeiro Domingues[2] and Ewertton de Souza Bezerra[1]

*[1]Laboratório de Biomecânica, Centro Desportivo, Universidade Federal de Santa Catarina, Campus Reitor João David Ferreira Lima, s/n, 88040-900, Trindade, Florianópolis, Santa Catarina, Brazil. [2]Grupo de Estudo de Pesquisa em Exercício e Nutrição em Saúde e Esporte, Universidade Estadual de Londrina, Londrina, Paraná, Brasil. *Author for correspondence. E-mail: nerysilas@gmail.com*

ABSTRACT. The objective of this study was to verify the influence of a concurrent exercise program with self-selected intensities, and order of exercise execution, on the cardiovascular indicators and functionality of medicated hypertensive patients. Seventeen individuals were allocated to one of two concurrent training groups: aerobic-resistance (7 men) and resistance-aerobic (3 men; 7 women). Each group underwent cardiovascular (heart rate, systolic and diastolic arterial pressure) and functional (Six minute walking test - 6MWT, Timed Up & Go test - TUG, flexibility and hand grip strength) evaluations pre and post training. The training occurred over 9 weeks. Resistance exercises were performed with an elastic tube and participants' body weight; self-selected intensity was supported by the OMNI-RES scale. The aerobic exercise was performed using a cycle ergometer with intensity measured by the Borg scale. A two-way ANOVA for repeated measures was used for comparisons between training programs, followed post hoc by the Bonferroni test, adopting $p < 0.05$. There were no significant changes in the cardiovascular and functional capacity indicators from pre- to post-intervention, and there were no significant interactions based on the order of the training program. The results suggest that a concurrent training program with self-selected intensity, regardless of order of training, may promote similar changes in cardiovascular and functional health indicators in individuals with controlled hypertension.

Keywords: resistance training, aged, hypertension.

Efeitos do treinamento concorrente com intensidade autosselecionada na aptidão física de hipertensos

RESUMO. O objetivo desse estudo foi verificar a influência da intensidade autosselecionada e a ordem do treinamento concorrente nos indicadores de saúde cardiovascular e funcional de hipertensos medicamentados. Participaram 17 indivíduos alocados em dois grupos de treinamento concorrente: resistência-aeróbio (3 homens e 7 mulheres) e aeróbio-resistência (7 homens). Antes e após o período de intervenção todos os participantes foram submetidos a avaliações de saúde cardiovascular (frequência cardíaca, pressão arterial sistólica e pressão arterial diastólica) e capacidade funcional (Teste de caminhada de seis minutos - 6MWT, Timed Up & Go test - TUG, flexibilidade e força de preensão manual). O treinamento concorrente ocorreu durante nove semanas. Os exercícios resistidos foram realizados com tubo elástico e próprio peso corporal com autosseleção da intensidade ancorada pela escala de OMNI-RES e o treinamento aeróbio em cicloergômetro ancorado pela escala de Borg. Anova *two-way* com medidas repetidas foi usada para comparar os resultados entre os grupos, com *post hoc* Bonferroni, adotando um $p < 0,05$. Não houve alterações significativas entre os programas de treinamento concorrente, antes e após o programa de intervenção nos indicadores de saúde cardiovascular e capacidade funcional. Os resultados sugerem que a ordem do treinamento concorrente com intensidade autosselecionada é promover alterações semelhantes nos indicadores de saúde cardiovascular e capacidade funcional em hipertensos medicamentados.

Palavras-chave: treinamento de resistência, idoso, hipertensão

Introduction

Systemic arterial hypertension is a multifactorial clinical condition characterized by elevated and sustained arterial pressure (He, Pombo-Rodrigues, & Macgregor, 2014; James et al., 2014). This condition is one of the main risk factors for the development of cardiovascular disorders, such as coronary artery disease, heart failure and cerebrovascular accident (i.e. stroke), which together are currently the main causes of death (Ettehad et al., 2016). Physical exercise has been recommended as a non-pharmacological therapy for the treatment of arterial hypertension because of its benefits for cardiovascular health and physical and functional fitness (Aoike et al., 2012; Goessler, Polito & Cornelissen, 2016).

According to the American College of Sports Medicine (Pescatello et al., 2004), physical training programs for hypertensive patients should include predominantly aerobic exercises, supplemented by resistance exercises. This is because aerobic exercises promote cardiovascular fitness and resistance exercises primarily promote musculoskeletal quality. Several researchers use aerobic and resistance training programs in the same training session, which is known as concurrent training (Cadore et al., 2010; Figueroa, Park, Seo, Sanchez-Gonzalez, & Baek, 2011).

The effectiveness of concurrent training in the prevention and treatment of cardiovascular problems has mainly been observed in the elderly (Ferrari et al., 2016; Tibana et al., 2014); where the low adherence of this population to systematic training may be related to a low response to exercise programs (Segundo et al., 2016). To increase adherence, some researchers have proposed the use of self-selected intensity for the prescription of resistance and aerobic training programs that are performed alone (Aoike et al., 2012; Glass, 2008).

Compared to controlled intensities, self-selected intensities have resulted in greater adherence to training programs since they allow for exercise to be more pleasant (Williams, 2008). However, the use of this strategy is questioned because it allows individuals to train with intensities that are below the stipulated limits to promote relevant physiological adaptations (Focht, 2007; Glass & Stanton, 2004). Still, some researchers have reported that the use of self-selected intensities may promote improvements in health indicators in elders or individuals with some type of associated pathology (Gault, Clements, & Willems, 2013; Moholdt, Bekken Vold, Grimsmo, Slørdahl, & Wisløff, 2012).

To date, there are no reports in the literature of studies that sought to investigate the effects of self-selected intensity in hypertensive individuals. Therefore, the objective of the present study was to verify the influence of a concurrent training program with self-selected intensities on the cardiovascular and functional health indicators of hypertensive elderly participants. The effect of the order of exercise type (aerobic-resistance- AR vs. resistance-aerobic - RA) was also assessed.

Methods

Experimental design

The experimental design is depicted in Figure 1. Initially, all participants performed preliminary assessments (pre-intervention) distributed over two meetings. The first meeting evaluated anthropometric measures; after 24 hours, cardiovascular and functional physical capacity evaluations were performed. These measures were also taken after the experimental program (post-intervention). Forty-eight hours after the preliminary assessment, the participants completed three resistance exercise familiarization sessions with the elastic tube. Prior to the start of the program, participants were randomly allocated to the following concurrent training groups: aerobic followed by resistance training (AR) and resistance followed by aerobic training (RA). By the end of the experimental protocol, 27 training sessions were carried out over 9 weeks, where there were 3 weekly sessions, with each session lasting 1 hour, from 5 to 6 pm or 6 to 7 pm.

Thirty recreationally active (Rhea, 2004) hypertensive patients, who were participants of an outreach program of the Federal University of Santa Catarina were eligible to participate in the study. However, thirteen (8 men and 5 women) elders did not complete the training program, resulting in 7 participants in the AR group (7 men) and 10 participants in the RA group (3 men and 7 women) (Table 1). Inclusion criteria were: over 50 years old with controlled hypertension (<140/90 mmHg, systolic and diastolic blood pressure, respectively). The exclusion criteria were: participated in structured resistance and/or aerobic training programs in the last 6 months; had congestive heart failure or a recent myocardial infarction; possess joint limitations that could compromise the movements of any exercise.

Before the beginning of the study, all participants were presented with a medical release for the practice of physical exercise. Each participant was informed of the research procedures and later signed an Informed Consent Form. The present study was approved by the ethics and research committee of the Federal University of Santa Catarina under protocol number 56386916.4.0000.0121.

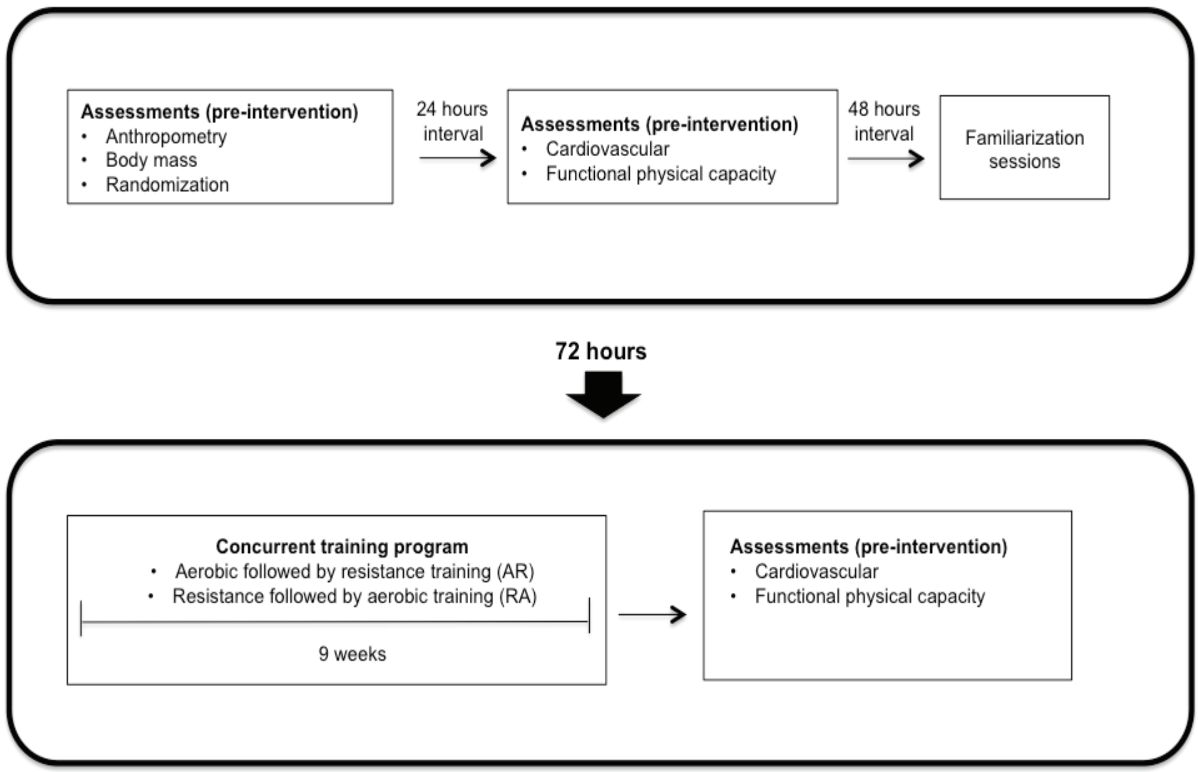

Figure 1. Experimental design.

Pre-experimental procedures

Anthropometric measures - Body mass and height were obtained through a digital scale (Filizola®, Brasil) and stadiometer (Sanny®, Brasil).

Blood pressure (BP) and heart rate (HR) – Brachial blood pressure was measured in triplicate on the left arm using an oscillometric device (Microlife®, Suíça, models BP 2AC1-1). This procedure has previously been validated (Lithell & Berglund, 1998), according to the Recommendations for Blood Pressure Measurement in Humans and Experimental Animals (Pickering et al., 2005). Heart rate was assessed using an HR monitor (Polar RS800CX, Polar Electro Oy, Finland).

Flexibility test – Lower limb flexibility was assessed by the chair sit and reach test, where the participants were first seated on a chair in such a way that they could come to the front edge of the seat while keeping their legs extended with ankle dorsiflexed. Second, they reached, with their hands for the toes of their extended legs and the examiner used a ruler (centimeters) to measure the distance between the participants' finger and the tips of the toes. Upper limb flexibility using back scratch test was assessed by asking the participants to bring their hands together (hands touching) on their back (one hand from above the shoulder and other hand from middle of back). A measurement (in centimetres) of the space between the extended middle fingers of the participants was taken.

Hand grip strength test – Hand grip strength was evaluated in right and left upper limbs by means of a palmar dynamometer (SAEHAM®). Participants were instructed to perform 3 grips, with a 10-second interval between each execution. The highest value measured was considered (Reis, Maria, & Arantes, 2011). This test was evaluated since studies have observed an association between low levels of manual grip and cardiovascular risk (Cheung et al., 2013; Mattioli & Cavalli, 2015).

In order to approximate the assessments of daily clinical practice, two validated field tests were used to evaluate aerobic capacity and agility in the elderly population (Casanova et al., 2011; Martinez et al., 2016).

Six-minute walk test (6-MWT) - The 6-MWT was performed following the standard recommendations (Britto, 2006), in an area with a length of 30 meters. Participants walked back and forth for 6 minutes and at the end of the 6 minutes, the number of complete turns was multiplied by 30 meters, plus the distance of the last turn, when not finished.

Time Up and Go Test (TUG Test) - The TUG test quantifies, in seconds, the time necessary for an individual to perform the task of getting up from a chair, walking 3 meters, turning, going back to the chair, and sitting again (Podsiadlo & Richardson, 1991).

Familiarization sessions - All familiarization sessions were performed after the initial assessments. They occurred on non-consecutive days with a 48-hour interval between them. All participants performed three sessions of familiarization to aerobic training and resistance training with an elastic tube. The aerobic training was performed on a cycle ergometer (BM 4000, *Movement*) for a duration of 25 minutes, where participants were exposed to different exercise intensities throughout the sessions, through the manipulation of load. Fifteen minutes after starting the exercise and at the end of the session, participants were asked to describe the effort with which they performed using the Borg CR-10 scale (Borg, 1982). During resistance training, 3 sets of each exercise were performed, with 20 repetitions per set and 20 seconds of recovery between exercises and sets. In each session, six exercises were performed: squatting with the elastic tube, ankle plantar flexion (calf muscles) while standing on a step, standing row with the elastic tube, standing paddle with the elastic tube, abdominal (trunk flexion) and pelvic elevation with the back resting on a mat; all exercises were adapted from the study of Colado and Triplett (2008). In each session, the participants tried different exercise intensities by manipulating the elastic tubes' distension; the closer to the elastic fixation point the easier the movement, and the further away, the more difficult the movement. At the end of each exercise, all participants were instructed to assign effort with a quantitative value of 1 to 10 or a qualitative value of "easy or light" to "extremely hard or heavy" through the Omnibus Resistance Exercise Scale (OMNI-RES) (Lagally & Robertson, 2006). Movement speed was controlled at all times, and was the same throughout the program (2 seconds concentric, 4 seconds eccentric).

Exercise program

The resistance training program consisted of six exercises, where each participant was instructed to perform exercises with and without the elastic tubes using the following training program: week 1-3 (1 series for upper limbs and 2 series for lower limbs), week 4-7 (2 series for upper and lower limbs), and 8-9 weeks (3 series for upper and lower limbs), where the recovery interval was always 20 seconds. The difficulty of the exercises with the elastic tube was set at the initial distension of the elastic tube for the execution of the exercise. All participants received a standard instruction on the process of self-selection: "choose a distance to perform 20 repetitions for the (name of the exercise).

The aerobic training program consisted of 25 minutes of exercise on the cycle ergometer at an intensity between 13 (slightly tiring) and 15 (tiring) on the Borg 6-20 scale (Borg, 1982). At no time did the exercise instructor intervene in the load chosen by the participant.

Statistical analyses

A Gaussian distribution was verified by the Shapiro-Wilk test. Baseline values between sessions were compared using the Paired Student t-test. A two-way analysis of variance for repeated measures was used for comparisons between training programs. Mauchly's sphericity test was used to verify the sphericity of the data. Considering the variables in which the sphericity was violated, the analyzes were adjusted by using the Greenhouse-Geisser correction. When necessary, a Bonferroni Post-hoc test was employed. SPSS version 21 for Windows was used for statistical analysis and a significance level of 5% was adopted.

Results

Seventeen participants completed the study; adherence to the training sessions was 85%. The characteristics of the participants are presented in Table 1.

Table 1. Physical and hemodynamic characteristics of the hypertensive participants included in the study (n = 17).

	AR (n =7)	RA (n =10)
Age (years)	56.7 ± 4.5	65.9 ± 7.3
Weight (kg)	82.1 ± 15.0	74.9 ± 16.9
Height (m)	1.67 ± 0.1	1.67 ± 0.1
SBP (mm Hg)	121 ± 10	122 ± 11
DBP (mm Hg)	80 ± 10	71 ± 8

kg – kilograms, m – meters, mmHg – millimeters of mercury, SBP – systolic blood pressure, DBP – diastolic blood pressure. Values described as mean and standard deviation.

All experimental baseline measurements were similar (Tables 2 and 3). Similar responses were found for lower limb flexibility, upper limb flexibility, the hand grip strength test, the TUG test, and the six-minute walk test (6-MWT) in both training programs (Table 2) ($p < 0,05$).

As shown in Table 3, there were no significant differences in systolic blood pressure, diastolic blood pressure, and heart rate when the two training programs were compared.

Figure 2 shows that there was considerable heterogeneity in SBP and DBP based on the order of the concurrent training. Some participants had a reduction of approximately 30 mmHg in SBP and DBP.

Table 2. Comparison between AR and RA groups on functional capacity indicators before and after nine weeks of the concurrent training program.

	AR (n=7)	RA (n=10)	Effects	p-value
Flexibility UL - Right (cm)				
Pre	-13 ± 15	-9 ± 12	Exercise	0.737
Post	-9 ± 12	-9 ± 11	Time	0.064
			Interaction	0.170
Flexibility UL - Left (cm)				
Pre	-19 ± 17	-13 ± 16	Exercise	0.722
Post	-11 ± 15*	-11 ± 14	Time	0.034
			Interaction	0.136
Flexibility LL - Right (cm)				
Pre	2 ± 6	2 ± 10	Exercise	0.898
Post	5 ± 9	4 ± 14	Time	0.148
			Interaction	0.596
Flexibility LL - Left (cm)				
Pre	4 ± 7	0.6 ± 12	Exercise	0.485
Post	9 ± 8	5 ± 15	Time	0.014
			Intereraction	0.790
Handgrip - Right (kgf)				
Pre	26 ± 11	28 ± 11	Exercise	0.766
Post	30 ± 11*	32 ± 13	Time	0.003
			Interaction	0.534
Handgrip - Left (kgf)				
Pre	30 ± 12	29 ± 9	Exercise	0.846
Post	34 ± 13*	33 ± 11	Time	0.008
			Interaction	0.748
TUG - test (s)				
Pre	5.4 ± 0.8	5.6 ± 0.6	Exercise	0.829
Post	5.8 ± 0.4	5.7 ± 0.8	Time	0.163
			Interaction	0.274
6-MWT (m)				
Pre	587 ± 66	615 ± 97	Exercise	0.584
Post	587 ± 63	605 ± 110	Time	0.745
			Interaction	0.751

cm – centimeters, UL – upper limb, LL – lower limb, kg – kilogram-force, m – minutes, s – seconds, AR – Aerobic training followed by resistance, RA – Resistance training followed by aerobic. Values reported as mean and standard deviation. *Significant difference Pre vs. Post- training program.

Table 3. Comparison between AR and RA groups on cardiovascular indicators before and after nine weeks of the concurrent training program.

	AR (n=7)	RA (n=10)	Effects	p-value
SBP (mm Hg)				
Pre	121 ± 9	122 ± 11	Exercise	0.610
Post	128 ± 19	132 ± 16	Time	0.124
			Interaction	0.758
DBP (mm Hg)				
Pre	80 ± 10	71 ± 8	Exercise	0.466
Post	73 ± 10	77 ± 10	Time	0.874
			Interaction	0.083
HR (bpm)				
Pre	76 ± 12	72 ± 10	Exercise	0.312
Post	72 ± 10	70 ± 8	Time	0.374
			Interaction	0.800

mmHg – millimeters of mercury, SBP – systolic blood pressure, DBP – diastolic blood pressure, HR – heart rate, bpm – beats per minute, AR – Aerobic training followed by resistance, RA – Resistance training followed by aerobic. Values of mean and standard deviation.

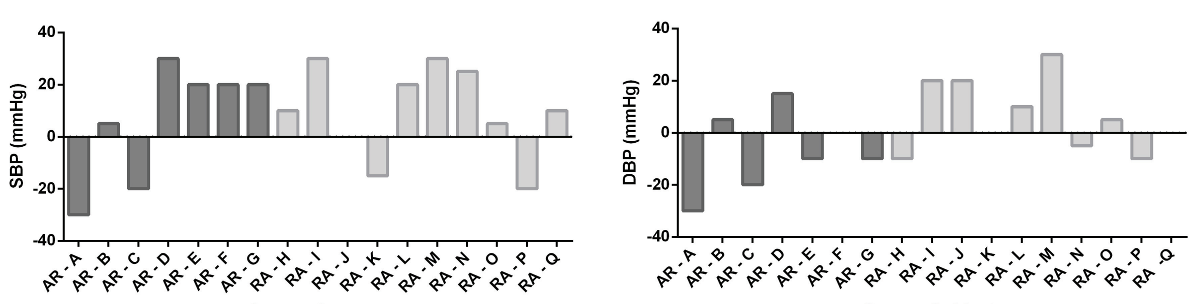

Figura 1. SBP – Systolic blood pressure, DBP – diastolic blood pressure. mmHg – millimeters of mercury. Letters A to Q represent each participant. AR – Aerobic training followed by resistance and RA – Resistance training followed by aerobic.

Discussion

The main finding of the present study was that the concurrent training programs using self-selected intensities, regardless of the order of exercise performance—aerobic followed by resistance (AR) or the reverse (RA)—promoted similar alterations in cardiovascular health and functional capacity indicators. Previous studies demonstrated that a self-selected intensity in unsupervised aerobic exercise programs, promoted an increase in cardiovascular fitness (Gault et al., 2013; Moholdt et al., 2012) and improved functional capacity (Aoike et al., 2012). Gault et al. (2013), demonstrated reductions in systolic arterial pressure, systolic volume, and arteriovenous oxygen demand in healthy elderly subjects after an acute session of aerobic treadmill exercise. However, other studies have shown that the use of self-selected intensities in resistance training have not been effective (Glass, 2008; Glass & Stanton, 2004).

The self-selected load for resistance training is below the accepted limit to generate an overload that leads to adaptations in muscular structure (Glass, 2008). That is, the performance of resistance exercises with a self-selected intensity has been shown to not increase muscle strength and hypertrophy (Focht, 2007). Elsangedy et al. (2013), observed that the self-selected load of sedentary individuals was enough to increase the strength of only sedentary individuals. In the study by Segundo et al. (Segundo et al., 2016) the self-selected intensity chosen by hypertensive elderly women was below the limit of 60% of the 1 maximal repetition recommended by the American Heart Association, therefore, no significant changes were observed.

The training program conducted in the present study likely did not result in positive effects on cardiovascular health indicators due to the intensity used for aerobic and resistance training, since the magnitude of cardiovascular and physical responses depends on the intensity, duration, and muscle mass involved during exercise. Exercise may be a limiting factor in promoting changes in the physiological system (Glass & Stanton, 2004; Nery et al., 2010).

Some studies have investigated the order of performance of concurrent exercise on cardiovascular health indicators (Lovato & Anunciação, 2012). In fact, our findings corroborate with those of studies that used exercises with higher intensities. This means that factors other than exercise intensity may be linked to the magnitude of cardiovascular adaptation in regards to the order of performance of concurrent exercises. However, meta-analytic studies have shown that concurrent exercise promotes blood pressure reductions (Cornelissen & Smart, 2013). At the same time, studies analyzing the isolated effects of resistance training on physical indicators, such as muscle strength, have demonstrated similar effects to training with imposed loads (Glass, 2008).

In view of this, we hypothesized that the RA training would promote greater reductions in cardiovascular health indicators than the AR, and the AR training would promote better results in functional capacity indicators compared to RA. However, the findings of the present study did not demonstrate such behavior, most likely due to exercise intensity, as previously described.

It was found that some participants were characterized as responsive in SBP and DBP, while others were not. After the training program, for SBP, 2 subjects were classified as responsive in the AR group and 2 in the RA group. For DBP, 4 individuals were responsive in the AR group and 3 in the RA group. Thus, although no significant effects have been found, different training orders seem to promote an effect on BP in the patients with hypertension. Therefore, factors such as weight, height, BMI and resting heart rate may be related to training responsiveness (Costa et al., 2016).

The type of implement used, the elastic tube, was a limitation in this study since the control of intensity with this type of implement is much more difficult compared to weights, where the required intensity may not have been sufficient to promote changes. As well, the lack of a control group made it impossible for us to compare the behavior of the health indicators evaluated. Finally, there was also a lack of control over the drugs used by the elderly participants.

Conclusion

The results of the present study suggest that the order of execution of concurrent training programs with self-selected intensities seems to promote similar changes in cardiovascular health indicators and functional capacity in elders with controlled hypertension.

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