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Original article

Strength training: the agreement between methodological standards and prescription by fitness professionals

Treinamento da força muscular: concordância entre os padrões metodológicos e a prescrição por profissionais do fitness

Francys Paula Cantieri[1], Gustavo Aires de Arruda[1], Diogo Henrique Constantino Coledam[2], Antonio Carlos Gomes[3], Ágata Cristina Marques Aranha[4], Mauro Virgilio Gomes de Barros[1], Marzo Edir Da Silva Grigoletto[5]

1. Universidade de Pernambuco, Recife, PE, Brazil
2. Instituto Federal de Educação, Ciência e Tecnologia de São Paulo, São Paulo, SP, Brazil
3. Instituto Olimpico Brasileiro, Rio de Janeiro, RJ, Brazil
4. Universidade Trás-dos-Montes e Alto Douro, Vila Real, Portugal
5. Universidade Federal de Sergipe, Aracaju, SE, Brazil

ABSTRACT

Introduction: The scientific advances have resulted in proposed methodologic standards to assist the prescription of physical exercise, but it is not clear whether there is a practical application of these standards by fitness professionals. **Objective:** To analyze the agreement between the methodologic standard for strength training and the methodology used by the fitness professionals. **Methods:** 461 professionals (men = 68.1%), aged 31.3 (± 6.8) years old, from the city of Londrina/PR and São Paulo/SP participated in the study, who filled out a questionaire containing 16 objective questions about strength training methodology. The Binomial test (cutoffs: 50% and 70%) was used for statistical analysis ($p < 0.05$). **Results:** Agreement significantly greater than 70% was obtained for 37.5% of the questions when considering agreement greater than 50%, plus 12.5% of the questtions were added. Agreements significantly less than 50% were identified for the number of repetitions for local muscle endurance (33.5%), load percentage for muscle power (39.5%), as well as for the rest interval for local muscle endurance (19.3%), hypertrophy (33.8%) and muscle power (20.3%). **Conclusion:** In general, the prescriptions indicated by fitness professionals had low agreement with the analyzed methodologic standards.

Keywords: resistance training; exercise; practice guidelines; physical fitness; health.

RESUMO

Introdução: Avanços científicos resultaram em padrões metodológicos propostos para auxiliar na prescrição do exercício físico, porém ainda não está claro se há aplicação prática de tais padrões por profissionais do fitness. **Objetivo:** Analisar a concordância entre padrões metodológicos para treinamento de força muscular e a metodologia utilizada por profissionais que atuam na área do fitness. **Métodos:** Participaram do estudo 461 profissionais (homens = 68,1%) com média de 31,3 (± 6,8) anos da cidade de Londrina/PR e São Paulo/SP, que preencheram um questionário contendo 16 questões objetivas sobre metodologia do treinamento de força. O teste Binomial (cutoffs: 50% e 70%) foi utilizado para as análises estatísticas ($p < 0,05$). **Resultados:** Concordância significativamente maior que 70% foi obtida para 37,5% das questões. Ao considerar concordância maior que 50% mais 12,5% das questões foram adicionadas. Concordâncias significativamente inferiores a 50% foram identificadas para o número de repetições para a resistência muscular localizada (33,5%), percentual de carga para potência (39,5%), bem como para o intervalo de recuperação para resistência muscular localizada (19,3%), hipertrofia (33,8%) e potência (20,3%). **Conclusão:** A prescrição apontada pelos profissionais que atuam com fitness em geral apresentou baixa concordância com os padrões metodológicos analisados.

Palavras-chave: treinamento resistido; exercício; diretrizes práticas; aptidão física; saúde.

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Correspondence: Francys Paula Cantieri, Rua Olavo Bilac, 72/1204, 51021-480 Recife PE. francyspaulapersonal@gmail.com

Introduction

The popularization of strength training stimulated the investigation of this phenomenon to identify its health benefits, as well as its applicability in the prevention and treatment of degenerative diseases related to physical inactivity [1,2]. Scientific evidence has pointed out many possible health benefits of strength training to different population groups at various stages of life. Among these effects are increase resting metabolic rate and a decrease of low-density lipoprotein [3], post-exercise hypotension [4], benefits in the neuromuscular system [5,6] along cognitive and mental health aspects [7].

In 2007, the descriptor "muscle strength" was introduced in the National Library of Medical Subject Headings and defined as the amount of force generated by muscle contraction. Stimuli of different magnitudes applied to the muscular system through strength training promote distinct functional and morphological adaptations in the body [8,9]. Therefore, the prescription process must be based on the aspect of the neuromuscular activity specificity, the percentage of musculature involved in the action, the type of fiber, muscle work and motor necessity [10,11].

The total training intensity is represented as the product of the total number of sets and repetitions performed in one session multiplied by the load used in each repetition [12,13] and directly depends on the rest interval adopted between the sets.

Muscle adaptations depend both on the type of program used and the manipulation of total training intensity [1,9,10,14]. It can alter the final result in the maximal muscle strength (MS) which could be described as the increase in the capacity to generate strength against maximum resistance, in muscle hypertrophy (MH) represented by an increase in muscle volume, local muscle endurance (ME) characterized by higher resistance to fatigue during prolonged efforts, as well as muscle power (MP) that could be defined as the ability of the neuromuscular system to overcome resistance by applying high contraction speeds [1,10,12,15,16].

Although there is the understanding that professional practice is guided by scientific knowledge acquired during academic training [17], there seem to be divergences between methodologic standards and the practical application of professionals. The knowledge of professionals about such guidelines was previously investigated [18,19]; however, to the best of our knowledge, there are no studies that verify the agreement between the scientific standards and professional practice. This information can contribute to professional practices, just like in the curriculum reformulation of higher education courses.

In this perspective, the present study aimed to analyze the agreement between the methodologic standards for muscle strength training and the methodology used by the fitness professional.

Methods

This is an observational study with a cross-sectional design as part of a larger project with data collected in 2014 over two months. All participants signed the consent form, and the study protocol was approved by the Human Research Ethics Committee No: 1.013.727.

Participants

The sample consisted of 461 Physical Education professionals who attend postgraduate courses in Londrina/PR or São Paulo/SP.

Only professionals enrolled in the Federal Council of Physical Education (CONFEF) were included in the study. Those who did not answer all of the instrument's questions regarding strength training or indicated more than one alternative for the same question were excluded from the analysis.

Instrument

A questionnaire was specifically constructed for this study containing 46 objective questions with six alternatives for each question [20]. For this study, were used 16 questions comprising aspects such as training method, motor performance, and exercise volume and intensity variables related to strength training variables, as described in chart I.

Chart I - Questions related to strength training variables

Questions	A	B	C	D	E	F
Load (% 1RM)						
1. What percentage of load do you prescribe to develop maximum strength?	1-20	21-40	41-60	61-80	81-100*	P.N.A
2. What percentage of load do you prescribe to develop endurance?	1-20	21-40	41-60*	61-80	81-100	P.N.A
3. What percentage of load do you prescribe to develop hypertrophy?	1-20	21-40	41-60	61-80*	81-100	P.N.A
4. What percentage of load do you prescribe to develop power?	1-20	21-40*	41-60*	61-80	81-100	P.N.A
Number of sets (average)						
9. How many sets of each exercise do you prescribe endurance?	1	2	3*	4*	>4	P.N.A
10. How many sets of each exercise do you prescribe for hypertrophy?	1	2	3	4*	>4*	P.N.A
11. How many sets of each exercise do you prescribe for maximum strength?	1	2	3*	4*	>4	P.N.A
12. How many sets of each exercise do you prescribe for power?	1	2	3	4*	>4*	P.N.A
Number of repetitions (average)						
13. How many repetitions per set do you prescribe maximum strength?	1-4*	5-8*	9-12	13-16	>16	P.N.A

Chart I - Continuation.

Questions	A	B	C	D	E	F
14. How many repetitions per set do you prescribe hypertrophy?	1-4	5-8*	9-12*	13-16	>16	P.N.A
15. How many repetitions per set do you prescribe power?	1-4*	5-8*	9-12	13-16	>16	P.N.A
16. How many repetitions per set do you prescribe endurance?	1-4	5-8	9-12	13-16	>16*	P.N.A
Rest interval (sec) (average)						
17. How much rest interval between sets do you prescribe for maximun strength?	≤ 30	31-45	46-60	61-90	>90*	P.N.A
18. How much rest interval between sets do you prescribe for endurance?	≤ 30	31-45	46-60	61-90*	>90*	P.N.A
19. How much rest interval between sets do you prescribe hypertrophy?	≤ 30	31-45	46-60	61-90*	>90*	P.N.A
20. How rest interval between sets do you prescribe for power?	≤ 30	31-45	46-60	61-90	>90*	P.N.A

P.N.A: I prefer not to answer; *the alternative considered to be in accordance with the standard

The instrument had acceptable test-retest reliability by Kappa test (fair to good), and Cronbach's Alpha was 0.8, the questions used were just those related to muscle strength training.

To respond to the objective of the present study and considering a large amount of information available regarding the prescription of strength training, it was decided to adopt the training standard described by scientific studies with international recognition for each strength training variable, as described in chart II.

Chart II - Description of the scientific training standard used as criteria for analysis of strength training

	Load (% 1RM)	Sets	Repetitions	Rest Interval (Sec)
Maximal strenght	81 - 100	3 - 4	1 - 8	≥ 90
Muscle local endurance	41 - 60	3 - 4	>16	> 60 - 120
Muscle hipertrophy	61 - 80	> 3	5 - 12	> 60
Muscle power	21 - 60	> 3	1 - 8	≥ 90

Adapted from: Garber *et al.* [1]; Ratamess *et al.* [9]; Schoenfeld *et al.* [10]; Verkhoshansky and Stiff [11]; Fleck and Kraemer [12]; Krieger [13]; Bird *et al.* [15]; Schoenfeld *et al.* [16]; Perterson *et al.* [21]; Schoenfeld *et al.* [23]; Kraemer and Ratamess [24]; Wernbom *et al.* [26]; Grgic *et al.* [27]; Bottaro *et al.* [28]; Hill-Haas *et al.* [29]

Procedures

All participants were instructed to answer all questions in the questionnaire, indicating only one of the options and, in case of doubt, when not solved, choose the option "Prefer not to answer (P.N.A). The collection was carried out in predetermined dates and times, during the intervals of the specialization classes and under the supervision of the researcher responsible for the study. No clarification on methodological doubts was provided to the participants also were not allowed consultations with specialized literature, or search sites.

The data were analyzed using measures of frequency for the 16 questions. For dichotomized questions, the confidence intervals of 95% for frequencies were performed with Bootstrap (1000 samples). The binomial test was used to verify if the proportion of participants who agreed or disagreed with the methodologic standards was significantly different (proportion 50%). Considering that 70% is an acceptable cutoff in several evaluation institutions, binomial tests were used to identify whether the proportion of professionals who agree with the methodologic standards differs significantly from these criteria [21]. The variables percentual of load (%), number of sets and repetitions and rest intervals between sets were analyzed for all types of strength. The level of significance adopted was $p < 0.05$. All analyses were performed with IBM SPSS Statistics for Windows, version 20 (IBM Corp., Armonk, N.Y., USA).

Results

The sample consisted of 314 men with an average age of 31.1 (± 6.6) years and 147 women with an average age of 31.4 (± 6.9) years.

Concerning the MS, a higher percentage of respondents opted for loads between 81 and 100% of 1RM, 3 sets, between 1 to 4 repetitions per set and adopted rest intervals above 90 seconds. For ME prescription, the majority opted for loads between 41 to 60% of 1RM, 3 series, between 13 to 16 repetitions and indicated between 31 to 45 seconds of the rest interval. The prescription aiming at MH presented a higher frequency for percentages of loads between 61 to 80, most use 4 sets, between 9 to 12 and rest interval varying from 46 to 60 seconds. Finally, for MP, most participants prescribed loads between 61 to 80% of 1RM, adopted 4 sets, with repetitions between 5 to 8 and a rest interval of 45 to 60 seconds (Table I).

In general, using the cutoff of 70% the MH presented the highest number of questions that showed significant agreement with three questions (75%) and a lower number of questions were found for ME and MP, both with just one question (25%). Considering the analysis by variables, the one with the highest number of questions that agree was the number of sets (75%) and the lowest was the rest interval, which did not present any question with a significant agreement (Table II).

From the cutoff of 50%, the MS was the variable with the highest number of agreement questions (100%) and the lowest number found for MP (25%). Considering only the variables of strength training, the number of sets showed 100% agreement of the questions and the rest interval was the one with the lowest number of agreement questions (25%) (Table II).

Table I - Frequency of responses in training variables (load, number of sets, number of repetitions, and rest interval) in the different strength training

Type of strenght	Load %	(%)	Nº Set	(%)	Nº Repetition	(%)	Rest Interval	(%)
MS	**1 - 20**	0.2	**1**	12.8	**1 - 4**	73.0	**≤ 30**	2.7
	21 - 40	0.3	**2**	15.2	**5 - 8**	17.3	**31 -45**	5.5
	41 - 60	3.3	**3**	30.8	**9 - 12**	4.2	**46 - 60**	8.4
	61 - 80	14.5	**4**	18.1	**13 - 16**	0.7	**61 - 90**	16.4
	81 - 100	78.6	**> 4**	17.6	**> 16**	0.4	**> 90**	62.1
	P.N.A	3.1	**P.N.A**	5.5	**P.N.A**	4.4	**P.N.A**	4.9
ME	**1 - 20**	0.5	**1**	0.4	**1 - 4**	4.9	**≤ 30**	16.0
	21 - 40	4.2	**2**	5.6	**5 - 8**	9.4	**31 - 45**	33.2
	41 - 60	52.8	**3**	44.5	**9 - 12**	10.5	**46 - 60**	28.1
	61 - 80	36.1	**4**	33.1	**13 - 16**	38.4	**61 - 90**	16.7
	81 - 100	3.1	**> 4**	12.8	**> 16**	33.5	**> 90**	2.6
	P.N.A	3.3	**P.N.A**	3.6	**P.N.A**	3.3	**P.N.A**	3.4
MH	**1 - 20**	0.0	**1**	0.2	**1 - 4**	3.4	**≤ 30**	7.5
	21 - 40	0.2	**2**	2.9	**5 - 8**	25.5	**31 - 45**	19.9
	41 - 60	5.7	**3**	36.8	**9 - 12**	61.5	**46 - 60**	36.6
	61 - 80	67.5	**4**	47.5	**13 - 16**	4.9	**61 - 90**	27.2
	81 - 100	21.8	**> 4**	10.4	**>16**	1.1	**> 90**	6.6
	P.N.A	4.8	**P.N.A**	2.2	**P.N.A**	3.6	**P.N.A**	2.2
MP	**1 - 20**	0.9	**1**	0.2	**1 - 4**	14.4	**≤ 30**	8.6
	21 - 40	12.2	**2**	2.9	**5 - 8**	32.4	**31 - 45**	15.7
	41 - 60	27.3	**3**	36.8	**9 - 12**	23.9	**46 - 60**	23.4
	61 - 80	30.2	**4**	47.5	**13 - 16**	15.5	**61 - 90**	21.6
	81 - 100	18.1	**> 4**	10.4	**> 16**	3.8	**> 90**	20.3
	P.N.A	11.3	**P.N.A**	2.2	**P.N.A**	10.0	**P.N.A**	10.4

MS = maximal muscular strength; ME = endurance; MH = hypertrophy; MP = power; P.N.A: I Prefer not to answer

Based on the results obtained by the binomial analysis, the proportion of agreement was significantly higher than 50% on the following questions: 1 and 3, related to (% of load MS and MH) 9, 10, 12, (sets ME, MH, MP respectively) 13 and 14 (repetitions MS and MH) and 17 (rest MS). Questions 2 (% load ME), 11 (sets MS) and 15 (repetitions MP) had similar proportions of agreement and disagreement. The proportion of agreement for questions 4 (% of load MP), 16 (repetitions ME), 18, 19 and 20 (rest ME, MH, MP respectively) was significantly less than 50%. Using the 70% cutoff point, it was observed that 37.5% of the questions agree with the standards, they are, questions 1 (% of load MS), 9, 10,12 (sets ME, MH, MP respectively), 13 and 14 (repetitions MS and MH). Questions 2 and 4 (% of load ME and MP), 11 (sets MS), 15 and 16 (repetitions MP and ME), 17, 18, 19 and 20 (rest MS, ME, MH, MP) were significantly below the cutoff point and only question 3 (% of load MH) it did not differ significantly from 70% agreement (table II).

Table II - Agreement between methodological scientific training standard for strength training prescription and fitness professionals' practice

Load	Agreement (%)	95%CI
Question 01 - MS	78.6	(75.1 - 82.2)*†
Question 02 - ME	52.8	(47.9 - 57.7)†
Question 03 - MH	67.5	(63.0 - 71.8)*
Question 04 - MP	39.5	(34.8 - 43.8)*†
Sets		
Question 09 - ME	77.6	(73.8 - 81.4)*†
Question 10 - MH	94.7	(92.5 - 96.7)*†
Question 11 - MS	48.9	(44.3 - 53.5)†
Question 12 - MP	81.1	(77.3 - 84.6)*†
Repetition		
Question 13 - MS	90.4	(87.7 - 93.0)*†
Question 14 - MH	87.0	(83.9 - 89.9)*†
Question 15 - MP	46.8	(42.1 - 51.4)†
Question 16 - ME	33.5	(29.0 - 37.9)*†
Rest		
Question 17 - MS	62.1	(57.6 - 66.3)*†
Question 18 - ME	44.8	(40.0 - 49.0)*†
Question 19 - MH	33.8	(29.1 - 38.0)*†
Question 20 - MP	20.3	(16.6 -24.1)*†

*Significantly different ($p < 0.05$) from desagree by Binomial test (proportion 50%); † Significantly different ($p < 0.05$) from reference cutoff (proportion 70%) by Binomial test. MS = maximal muscular strength; ME = endurance; MH = hypertrophy; MP = power

Discussion

Professionals, in general, do not prescribe strength training according to scientific recommendations. A relevant proportion of questions showed agreement below the minimum cut-off point adopted. Considering the type of adaptation, muscle hypertrophy was the training that showed the highest agreement, while the muscle power training was the one that showed the lowest agreement with the scientific training standards. When observing the training variables regardless of the type of training, the one with the highest number of concordance questions was the number of series and the rest interval was the variable that showed the least agreement with methodologic standards.

Although there is no cut-off point established in the literature regarding the agreement between the prescription adopted by the professionals and the scientific recommendations because it is not objectively an assessment of the knowledge, it was expected that most professionals would answer the questions in a manner corresponding to the methodologic standard.

Studies suggest that MS training should prioritize loads close to maximum capacity, with a number of average sets, reduced number of repetitions and intervals above 90 seconds, to promote neural adaptations with increased recruitment of motor units and optimization of intramuscular coordination [9,11,12,22-24]. In the present study, all questions related to the variables of the training of MS presented agreement greater than 50%, with emphasis on the percentage of load and number of repetitions that exceeded 70% of agreement.

Considering the ME, only two of the four variables analyzed had an agreement greater than 50% and only the number of sets exceeded the cutoff point of 70%. In general, it was expected that, if not all, most variables would obtain an agreement greater than 70%, since the literature indicates the development of ME in all areas of physical exercise, due to its relevance in maintaining the parameters health of individuals, as well as in the general phases of sports training, due to its preparatory nature for the development of other types of specific training. The low agreement observed evidence the need for future studies that aim to diagnose the importance attributed by professionals to the development of endurance for health and sports performance and the frequency with which these prescriptions are carried out.

It is essential to highlight the high percentage of professionals who opted for the number of repetitions between 1 and 12, and a rest interval below the recommended. The training aimed at increasing local muscle endurance requires a high number of repetitions with not too long intervals, which allow partial recovery of energy substrates and promote an increase in mitochondrial and capillary numbers, fiber type transitions and buffer capacity [1,12,15,25]. The portion of professionals who opted for very short intervals may be referring to circuit training, however, the recommendation for this type of prescription suggests lower loads than those indicated by professionals [12].

The scientific literature advises that training aimed at hypertrophy should be programmed with loads between 60 to 80% of maximum capacity, with a number of sets greater than 3 and repetitions ranging from 5 to 12, with rest intervals above 60 seconds.Three of the four questions, percentage of load, number of sets and repetitions related to MH were in accordance with the standard above 70% [1,9,11,13,26], with only the question regarding the agreement rest interval being presented below 50%. This high agreement observed between professionals' prescriptions and scientific recommendations can be justified by the fact that it is a training modality widely used among professionals both for health promotion and sports performance. In addition, the preference of practitioners for stronger and muscle definition can lead professionals working with fitness to prioritize this type of prescription. This interest observed in practice is reflected by the high number of scientific papers published annually on the subject.

It was expected that the rest interval would also show an agreement greater than 70%, since the adequate rest interval is essential for the good development of muscle hypertrophy. Results indicate that intervals longer than 60 seconds allow the energetic substrates to be adequately replaced in the muscle in action [1,12,27-30] and shorter intervals can generate early fatigue and impair the performance of subsequent series and not allow significant gains in hypertrophy [29,30]. However, in the present study, these standards were adopted by less than 40% of professionals.

When analyzing the prescription for the development of MP, only the question regarding the number of sets had an agreement greater than 70%. The questions related to the percentage of load and rest interval were below 50% of the scientific recommendations. The MP occurs when a greater number of movements is performed in a certain period of execution or when the same number of movements is performed in a shorter period [11]. In this sense, the recommendation for the development of MP involves moderate loads not exceeding 60% of 1RM with a rest interval similar to those proposed to develop maximum strength (≥ 90 seconds) allowing adequate replacement of muscle phosphogen [1,9,11,12].

The development of MP through traditional training has good results, however, the current literature proposes other alternatives as efficient forms of training that were not included in this questionnaire, such as plyometrics. In addition, strength training is generally related to sports performance and most professionals who took part in this study develop physical fitness programs focused on health. These particularities related to MP training may explain the low agreement observed in most of the analyzed variables.

The low agreement observed in the present study between the prescription of variables that make up a strength training program and scientific recommendations is worrying, since such recommendations, proposed with a high level of scientific evidence, seem to be neglected by most fitness professionals.

The exponential increase in the number of university students in physical education courses observed in recent decades and the low rate of failure, associated with the curricular contents of academic training that do not include every phenomenon observed in practice, can influence the prescription made by professionals. The absence of a single guideline can make the process of professional training difficult, as it does not allow for adequate preparation for evidence-based decision-making. On the other hand, the ease of access to content through digital platforms, which in some cases disclose information with low scientific rigor, can influence professionals in their decisions.

In the present study, only one component of the training was evaluated, however, it should be considered that its prescription occurs concomitantly with the other components of physical fitness. In addition, the form of prescription was analyzed through a questionnaire, not allowing to verify its applicability in the real context. However, the use of this type of instrument allows the analysis of large samples.

Regarding the choice of the 70% cutoff point, it may not indicate an ideal proportion of agreement in all contexts, but it is a reference widely used in several academic evaluation processes, as the minimum acceptable. Another aspect to be considered is that the present study may not represent the level of knowledge of Brazilian professionals, since the professionals who participated in the research were already at a postgraduate training level. Finally, it was not evaluated whether the 1RM load was obtained using any specific tests or by predictive equations.

Conclusion

A low agreement was observed between the professional prescription and the training standards proposed in the scientific literature. Muscle hypertrophy was the training that showed the highest agreement, while endurance and power training were the ones that least agreed with the recommendations. When considering the training variables regardless of the type of training, the one with the highest number of concordant questions was the number of sets and the rest interval was the variable that showed the least agreement with the methodologic standards.

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Authors' contributions
Conception and research design: Cantieri FP, Gomes AC, Aranha ACM; **Obtaining data:** Cantieri FP, Arruda GA; **Data analysis and interpretation:** Cantieri FP, Arruda GA, Aranha ACM, Coledam DHC; **Writing of the manuscript:** Cantieri FP, Arruda GA, Coledam DHC, Gomes AC, Barros MVG, Silva-Grigoletto ME. **Statistical analysis:** Arruda GA, Gomes AC, Barros MVG; **Critical revision of the manuscript for important intellectual content:** Silva- Grigoletto ME, Barros MVG, Aranha ACM

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