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UPDATING EXERCISE PRESCRIPTION IN HEALTH AND DISEASE

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(Original scientific paper)

Natàlia Balagué[1], Maria del Carmen Almarcha[1], Robert Hristovski[2]
1Universitat de Barcelona, Institut Nacional d'Educació Física (INEFC), Barcelona, Spain,
[2]Ss. Cyril and Methodius University, Faculty of Physical Education Sport and Health, Skopje, Macedonia

Abstract

An international consensus has resulted in the prescription of homogenous exercise programs for healthy and clinical populations with different pathologies. This generic prescription, based on concrete doses of aerobic and strength training, has proved to be safe and efficacious across a diverse range of populations. However, the personalization of such prescription may become problematic due to the excessively simplistic or even wrong assumptions behind such universal recommendations and their research evidence. The aim of this paper is to review these assumptions on the basis of complex systems science and network physiology, and update the current exercise prescription accordingly. First, we describe the one-size-fit all approach of current recommendations and question the rationale of the scientific evidences behind. Afterwards we update the basic assumptions related to the conception of the organism, the concept of health and fitness, the objectives and principles of training, the assessment of physiological states, the role of coaches and patients and the research methodology. According to it we propose alternative general recommendations for exercise prescription in health and disease.

Key words*: exercise guidelines, scientific paradigms, exercise is medicine, connectivity, complexity*

Introduction

Physical activity has become an important health issue in modern society and there is a boom of the fitness industry affording facilities and exercise programs. Selecting an adequate program is a main issue and a growing body of work has investigated the efficacy of exercise therapy in many different scenarios. On the basis of the available research, the American College of Sports Medicine (ACSM) and the World Health Organization (WHO) have converged on a recommendable type of activity and minimum dose in their guidelines for exercise prescription in health and disease (Riebe, Ehrman, Liguori, & Magal, 2018; WHO, 2019). Curiously, both institutions concur in a universal recipe with light adaptations in function of the age and type of disease of the population.

Following a biomedical model, the universal recipe consists on aerobic exercise, either alone or in combination with resistance training, practiced at a moderate intensity a minimum of 150min/week(3 to 5 days/week) with bouts lasting at least 10 min duration. Due to the assumed dose-response relationship, for a more intense effect, the volume can be enlarged until 300min/week, or reduced to 75 minutes/week if the exercise is more vigorous. Muscle strength training, performed at moderate or high intensity, and practiced 2 days a week provides additional health benefits (Riebe et al., 2018).That is, the recommendation assumes that fitness for health is reducible to endurance and strength dimensions and that the organism responds to linear dose-response relationships.

Why the current recommendations?

These aerobic and strength programs have proven its efficacy and safety across a diverse range of populations. However, a systematic review of exercise prescription works reveals that even though most studies present favourable results, there is a lack of evidence in several fields and a lack of high-quality studies evaluating its sustainability in everyday use (Sørensen, Skovgaard, & Puggaard, 2006).

Other criticisms addressed to the available research testing the effectivity of the recommended standardized aerobic and strength exercise programs and their basic assumptions can be summarized as follows:

1) *Exercise testing informs about physiological stable states*. Contrary to this assumption, physiological states are not stable. They evolve in time and suffer non proportional changes when perturbed by

internal or external factors. This means that individuals may present different testing results, not attributable to training, under apparent "similar" conditions.

2) *The tested variables have sufficient reliability and sensitivity*. The problems of biological and measurement variability of goal standards fitness markers like VO_2max have been widely discussed (Beltz et al., 2016). In addition, new variables of study, based on the co-variation of time series of cardiorespiratory variables, seem to be more sensitive to interventions than VO_2max. (Garcia-Retortillo et al., 2019).
3) *There is equivalence between inter- and intra-individual variability*. Most of the available research on exercise prescription compares snapshots of inter-individual variations through group data means. These results are erroneously extrapolated to the intra-individual variability neglecting the idiosyncrasy of the structure of time-dependent variations within a single individual. Because of this, accurate pooled data based individual developmental predictions are not possible for a vast set of variables (Molenaar, 2004; Nesselroade, & Molenaar; 2010; Rose et al. 2013; Rose, 2016).
4) *Research results are context free.* A bench to bedside approach, applying directly research results obtained in lab conditions, even in the treatment of patients, is common in exercise prescription. In particular, chronic diseases are complex scenarios that cannot be reproduced in lab conditions.Due to this context-dependence, exercise programs may produce a different impact in real contexts and lose effectivity. The physical environment (e.g., safety, air quality, conditions of sidewalks and parks), social environment (e.g., social connectedness, social support, presence of community programs), and family and individual factors (e.g., socio-economic status and occupation) directly affect fitness and health (WHO, 2019)
5) *Generalization of research results is possible without a representative random sample of participants.* The possibilities of generalization of research results are also limited because only few studies on exercise prescription involve a random sample of participants (Sorensen et al., 2006).
6) *Experimental designs and group data means provide the best research evidence*. Assuming cause-effect relationships between training programs and exercise benefits, experimental designs ignore the multidimensionality of fitness and health.As the effects of exercise therapy are usually compared against a non-intervention control group with a sedentary lifestyle of recognized deleterious consequences, the positive results of standardized programs may be overrated.In addition, while some participants of the experimental group may present large improvement other may even present deleterious effects (Rose, 2016).
7) *Only quantitative changes matter.* Fitness evaluations are focused on quantitative data ignoring completely qualitative changes (Strumberg et al., 2019). Considering the dynamic and nonlinear nature of the systems we deal with, although it might be no changes in health benefits for a substantial change of training volume or intensity, for a small change,not just a quantitative, but aqualitative change may occur.
8) *Statistical difference means real difference.* The false belief that crossing the threshold of statistical significance is enough to show that a result is 'real' has led scientists and journal editors to privilege such results, thereby distorting the literature and leading to wrong interpretations (Wasserstein et al., 2016; Amrhein et al., 2019).
9) *Reviews and meta-analysis reduce the bias of the reviewed research.* Meta-analyses and systematic reviews do not reduce but may enlarge the bias of studies that compound it (Weir et al., 2016).

Changing assumptions. A complex dynamic systems perspective

On the basis of complex dynamic systems approach and particularly the network physiology, an outline of new conception of the organism properties, the meaning of health, the role of the context, the evaluation tools, the exercise and health relations and the role of health care professionals and users/patients is provided. A proposal of new exercise recommendations for health and disease follow form such new assumptions.

According to the conceptualization of users/patients as complex adaptive systems interacting dynamically and nonlinearly with exercise parameters, and presenting a high sensibility to changing contexts, a high inter and intra-individual variability in the adaptation to standardized training programs should be expected (Mann et al., 2014). It is important to remark that the current participation of the consumers in the design of the prescribed exercise programs is limited; they are mainly considered as mere executers. Due to the dynamic nature of the training intervention, different internal and external factors to

the person may change at very fast timescales (Balagué et al., 2019). These fast changes, hard to capture through external monitoring, require the development of body awareness skills of users/patients. To improve the adherence to exercise it is crucial that users/patients, progressively educated in body awareness from earliest age, contribute to co-design and co-adapt in space and time the proposals of health care professionals (Sturmberg et al., 2019).

The concept of health becomes also dynamic, and is considered an emergent state arising from nested networks interactions (Strumberg et al., 2019). In turn, fitness is defined in biological terms, and thus, it is not just reduced to endurance and strength dimensions. The diversity potential (Hristovski, 2017), providing more chances to survive in a broad range of contexts, embraces multiple dimensions (Pol et al., 2020). The subjective perception of health and fitness,associated with morbidity and mortality, is of utmost importance (Strumberg, 2019). Acknowledging that there is no a universal way to develop fitness, physical activities should be meaningful for the user/patient to promote adherence, and periodization of workloads as well as resting periods should be adapted on a moment to moment basis according to their immediate capabilities and context. The self-regulation is the final aim of the program intervention and thus, the health care professionals are encouraged to guide users/patients from dependency to autonomy.

Updating current recommendations

Gaining diversity through the development of socio-psycho-biological synergies should be a main aim of the prescribed PA program. With respect to the doses, the recommendation of an active life with varied stimulus, preferably at open air, seems preferable than reducing the PA to 75-150 min/week repeating exercises. As synergies are better captured through the interactions among the involved components and processes, variables related to connectivity, as the number and strength of couplings, can be suitable to test the PA program effects. As different components of the network cooperate to accomplish the common fitness goal, if the number and the functional strength of couplings is changed, the components of the network become overwhelmed. That is, they respond less effectively to social, psychological and physiological perturbations, bringing about a cascade of dysfunctional changes and increased susceptibility to disease.

Conclusion

From the complex dynamical systems approach there are no universal recipes of exercise for health. Universal, and hence general, are only dynamical principles underpinning the intra-individual variability. However, the intra-individual variability structure is idiosyncratic due to the additional influence of a vast number of socio-psycho-biological constraints. Fitness interventions, therefore, should develop the individual diversity potential and affect its multiple dimensions. They should be meaningful for the user/patient, contextualized and personalized in space and time. Users/patients should not be treated as mere executors of the intervention program but cooperate in its design and continuous adaptation. This should be crucially based on the development of their body awareness monitoring abilities from an early age as a key aspect to reach autonomy and make possible the PA self-regulation of users/patients. The research of new testing variables related to connectivity measures is warranted to more sensitively evaluate the fitness state, its changes and the effects of the updated recommendations.

Conflicts of interest -The authors declare no conflicts of interest.

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