BMJ Open Sport & Exercise Medicine

# Next steps to advance general physical activity recommendations towards physical exercise prescription: a narrative review

Raúl Ricardo Festa ,[1] Emilio Jofré-Saldía ,[2,3] Alejandro A Candia ,[2] Matías Monsalves-Álvarez ,[2,4] Marcelo Flores-Opazo ,[2] Luis Peñailillo ,[5] Gabriel Nasri Marzuca-Nassr ,[3,6] Nicolas Aguilar-Farias ,[7] Nicole Fritz-Silva ,[3,8,9] Jorge Cancino-Lopez ,[10] Johana Soto-Sánchez ,[11] Carlos Sepulveda,[12,13] Álvaro Huerta Ojeda ,[14] Cristian Núñez-Espinosa ,[3,15,16] Denisse Valladares-Ide ,[2,3] Sebastian Jannas-Vela [2,3]

**To cite:** Festa RR, Jofré-Saldía E, Candia AA, *et al*. Next steps to advance general physical activity recommendations towards physical exercise prescription: a narrative review. *BMJ Open Sport & Exercise Medicine* 2023;**9**:e001749. doi:10.1136/bmjsem-2023-001749

RRF and EJ-S contributed equally.

Accepted 6 October 2023



For numbered affiliations see end of article.

**Correspondence to**
Dr Sebastian Jannas-Vela; sebastian.jannas@uoh.cl and

Dr Denisse Valladares-Ide; denisse.valladares@uoh.cl

## ABSTRACT

Physical inactivity is a major health concern, associated with the development of several non-communicable diseases and with an increased mortality rate. Therefore, promoting active lifestyles has become a crucial public health necessity for enhancing overall health and quality of life. The WHO guidelines for physical activity (PA) present valuable contributions in this respect; however, we believe that greater specificity should be added or complemented towards physical exercise (PE) testing, prescription and programming in future recommendations. In this review article, we suggest simple and practical tools accessible to the entire population to improve the specificity of this approach, highlighting aspects of PE programming used by trained subjects. By adopting these suggestions, exercise professionals, clinicians and physical trainers can optimise the current general PA recommendations towards PE prescription to improve fitness status and encourage PE adherence in the general population.

### WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Current WHO physical activity (PA) guidelines have a general approach.
⇒ Aerobic PA is recommended to be performed at a certain intensity level, expressed in terms of metabolic equivalents of tasks and the rating scale of perceived exertion (RPE; ie, 0–10 scale).
⇒ Muscle-strengthening activities are recommended to be performed at moderate or greater intensity, engaging all major muscle groups.
⇒ In terms of programming, it is recommended to dedicate a minimum total amount of weekly volume for aerobic and muscle-strengthening activities.

### WHAT THIS STUDY ADDS

⇒ Future PA guidelines should be individualised towards physical exercise prescription.
⇒ Aerobic exercise should be prescribed based on defined physiological markers. The RPE and the talk test are simple and effective surrogate physiological markers for aerobic exercise prescription in the general population and physically inactive subjects.
⇒ Resistance exercise (RE) should be prescribed based on movement velocity and velocity loss. The RPE, level of effort, and repetitions in reserve are accessible tools to monitor and prescribe RE.
⇒ For aerobic exercise programming, the training intensity distribution model used by endurance athletes can be applied to the general population and physically inactive subjects. For RE programming, the use of light, moderate, or heavy loads must be prescribed according to the daily tasks and needs of the individual.

## INTRODUCTION

Physical inactivity (PI) refers to an insufficient physical activity (PA) level to meet current recommendations and is considered a contemporary pandemic in public health.[1 2] It is a major risk factor for non-communicable diseases (NCDs), accounting for approximately 41 million deaths per year worldwide.[3] PI is also associated with an estimated 11% of aggregate healthcare expenditures,[4] resulting in a total cost of approximately $47.6 billion per year.[5] Globally, it causes 6%–10% of NCDs, including coronary heart disease, type 2 diabetes, and breast and colon cancers,[6] and a total of 7.2% and 7.6% of all-cause and cardiovascular disease mortality, respectively.[7] Moreover, the ageing process and decline in PA levels lead to sarcopenia, which is associated with an increased risk of premature death.[8] Therefore, the regular practice of PA or exercise is the best tool for preventing and managing NCDs and overall health.[9]

**HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY**

⇒ This study presents a link between health and exercise research and clinical practice, supported by robust scientific evidence. The adoption of a customised approach, facilitated by practical tools, can yield substantial gains for professional practice, allowing the general population to benefit from the advantages of physical exercise.

The current WHO guidelines on PA described by Bull *et al* recommend performing aerobic-type and resistance-type exercises for overall health-related benefits in the general population >18 years of age.[1] While these guidelines have a valuable approach for the promotion of PA, we believe that greater specificity should be added or complemented towards physical exercise (PE) testing, prescription and programming in future recommendations (table 1). In the following sections of this review, we will develop an approach that guides current PA recommendations toward PE prescription and programming by incorporating simple and practical tools for self-management and optimisation, aiding those on healthcare or training centres and professionals who do not have adequate testing equipment for PE prescription and programming.

## METHODS

### Equity, diversity and inclusion statement

The present narrative review comprises clinical trials, randomised controlled trials, meta-analyses, systematic reviews and narrative reviews, covering individuals of all genders, ethnicities and socioeconomic levels in the topic of exercise testing, prescription and programming. The research methods were not adjusted for regional, socioeconomic, fitness or health status differences. The team of authors is made up of three women and thirteen men, with an outstanding professional career and extensive experience in the field of sports, exercise and health science research.

### Article search

The purpose of this review is to propose simple and practical tools for the improvement of current PA guidelines by including components of PE testing, prescription and programming. A search of the PubMed, ScienceDirect, SPORTSDiscus and Google Scholar databases was conducted using the following keywords: physical activity, physical exercise, exercise prescription, exercise testing, exercise programming, endurance training, endurance training intensity distribution, strength training, and resistance training in research and review articles. Only articles published from 1990 to 2023 were included, yielding a total of 78 938 results. After removing duplicate articles using the Mendeley software, a total of 24 865 articles were considered. Of these, 2039 articles were closely related to the review subject according to the title. After reviewing their abstracts, a total of 224 full-text articles were analysed. Finally, a total of 65 articles were selected to develop the manuscript. This review was written according to the SANRA narrative review assessment scale.[10]

## AEROBIC EXERCISE

### Testing and prescription

According to the WHO 2020 guidelines, aerobic PA performed at moderate and vigorous intensities refers to any bodily movement involving large muscles performed at an intensity between 3 to <6 and ≥6 times the resting energy equivalent expended (metabolic equivalent of tasks; METs), respectively.[1] This categorisation is useful for providing overall recommendations; however, it has some limitations when categorising PA at relative intensities based on fixed METs, as it does not account for individual differences in fitness level, body mass, age and sex, among other factors.[11 12] Further, exercising at a fixed MET or relative percentage of maximal oxygen uptake ($\dot{V}O_{2max}$) is not optimal because, in some cases (ie, poor fitness levels), performing moderate to vigorous-intensity exercises (ie, ~6 METs) represents intensities close to $\dot{V}O_{2max}$,[11] generating different levels of cardiac and metabolic demands[13 14] that could lead to discomfort

**Table 1** WHO recommendations on physical activity and suggestions to incorporate in future guidelines

| | Current WHO recommendations | Suggestions to incorporate in future guidelines |
|---|---|---|
| Aerobic exercise | For substantial health benefits, adults should get at least 150–300 min of moderate-intensity aerobic physical activity, or at least 75–150 min of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate-intensity and vigorous-intensity activity throughout the week | Physical exercise testing, prescription, and programming, with the training intensity distribution approach used by endurance athletes, based on defined physiological markers determined by simple and practical tools |
| Resistance exercise | For additional health benefits, adults should also perform muscle-strengthening activities at moderate or greater intensity involving all major muscle groups on two or more days a week | Physical exercise testing, prescription and programming with specific loads associated with daily needs (ie, light, moderate or heavy) based on the level of effort determined by simple and practical tools |

and higher unplanned stress. Therefore, it is advocated to associate moderate and vigorous-intensity exercises with individualised homeostatic disturbances, such as ventilatory or lactate thresholds 1 and 2 (VT1, VT2, LT1 and LT2, respectively),[15] and thus we suggest including these definitions in future guidelines for aerobic exercise prescription at the individual level in populations with different health conditions. However, we recognise that these fitness assessments are usually not available or easy to understand for the general population, so it is essential to provide tools that are accessible to everyone. Nonetheless, we emphasise the importance of educating the general population about their fitness level, PE testing and prescription, as well as having access to assessments in healthcare or training centres.

In line with the above, a positive addition to the WHO 2020 guidelines is the use of the rating scale of perceived exertion (RPE) in the definitions of PE intensity. A study conducted on 2560 subjects (13–83 years old), including both sexes and different fitness statuses, showed that during incremental aerobic exercise tests, the mean values for LT1 and LT2 were closely associated with an RPE (6–20 Borg's scale) of ~10.8 and ~13.6, respectively.[16] Similarly, during a progressive aerobic exercise test, RPE values of ~4.3 and ~6.5 (0–10 scale) corresponded to blood lactate (BLa) levels of 2 and 4 mmol/L, respectively.[17] Importantly, this approach is not only limited to traditional aerobic exercise modalities like walking, running or cycling but also to effective and recently evaluated outdoor fitness equipment (OFE) exercises (ie, air walker and ski machine),[18] where low, moderate and high RPE values can be achieved by manipulating the cadence of movement[19] and consequently regulate exercise intensity. Moreover, the use of RPE for intensity distribution allows to determine specific training zones for aerobic exercise testing and prescription, consistent with the typical three-intensity zone model used by endurance athletes (zone 1 (Z1): <LT1/VT1; zone 2 (Z2): ≥LT1/VT1 up to ≤LT2/VT2; zone 3 (Z3): >LT2/VT2),[20 21] and its use should continue to be recommended. However, because the RPE in subjects with health complications shows only a good agreement with BLa concentrations at low-intensity exercise,[22] we suggest caution when professionals prescribe moderate and high-intensity exercises based on RPE in these populations.

To reinforce future guidelines, we also suggest the incorporation of the 'Talk Test' (TT) as a simple way to regulate PE intensity.[23] The TT asks the participants how comfortable they feel speaking during exercise, and its use has been associated with low (≤2 mmol/L; *speaking comfortably*), moderate (~3–4 mmol/L; *not speaking comfortably*) and high (>5 mmol/L; *unable to speak comfortably*) levels of BLa during continuous aerobic type exercise, and has a close relationship with RPE[24] and VT1 or gas exchange threshold.[25] Moreover, the use of the TT can be extended to different populations, including cardiac patients,[26] overweight and obese people[27] and elite athletes,[28] where the use of an analogue scale can strengthen this approach.[27] However, it is important to highlight that the RPE and TT must be approached individually according to the type of exercise prescribed. In support of the use of the RPE and TT, recently Bok *et al* reported that both instruments are reliable and valid measures for the demarcation of ventilatory and lactate thresholds and can be used to elicit homeostatic disturbances associated with moderate, heavy and severe-intensity domains during continuous exercise.[29] Therefore, the TT could be added as another practical and inexpensive method for professionals to determine specific training zones for aerobic exercise testing and prescription in a simple and fairly accurate manner. In a practical way, professionals can recommend for people to talk with others or simply repeat a standardised sentence during the exercise session and thus easily know at what intensity zone they are exercising.

## Programming

Notably, one aspect of the WHO 2020 guidelines that we believe could be further complemented relates to aerobic exercise programming. Even though it is mentioned that 'many of the benefits of physical activity are observed within average weekly volumes of 150–300 min of moderate-intensity or 75–150 min of vigorous-intensity, or an equivalent combination of moderate-to-vigorous physical activity', we consider that the current recommendations may be more precise for exercise programming by adding a fundamental aspect, which is the training intensity distribution (TID), and not only total amounts of weekly PA. Olympic medallists in endurance and mixed sports,[30] and elite athletes live longer than the general population and have a lower risk of mortality, cardiovascular disease and cancer.[31] Interestingly, endurance athletes typically adopt a TID programme where ~80% of the training volume is performed at low-intensity (ie, <LT1/VT1) and the remainder (~20%) at moderate to high-intensity (ie, ≥LT1/VT1) under a pyramidal (Z1>Z2>Z3) or polarised (Z1>Z3>Z2) model with a hard day-easy day approach.[20 32 33] Although athletes perform higher training volumes (hours/week; km/week) than untrained individuals,[34] we think that the use of the TID model in the general population could be a promising approach. Notably, recent evidence shows that in overweight/obese women (21±2 years, body mass index 32±3 kg/m$^2$), a combination of high-intensity interval training (HIIT; 90% $\dot{V}O_{2peak}$) and moderate-intensity continuous endurance training (MICT; 95% VT1) in a polarised intra-session volume distribution, similar to the TID model used by athletes, is a more effective exercise regimen compared with HIIT or MICT alone, for improving cardiorespiratory fitness and to counteract the cardiometabolic risks associated with overweight and obesity.[35] According to current guidelines, MICT (low-intensity training in the three-zone model)[20] can be prescribed in bouts of any duration,[1] yet longer continuous bouts of 10 min or more may be more beneficial.[36 37] Regarding interval training during moderate-intensity to

high-intensity exercise, we recently proposed that long intervals (ie, ≥1 to 2 min) with ≥1 min recovery period should be prescribed for greater adaptations.[38] Certainly, more evidence is needed regarding aerobic exercise programming and the use of the TID model in physically inactive subjects or with health complications; however, we believe it is essential to include more details regarding aerobic exercise programming in future WHO guidelines.

In summary, the use of the RPE for intensity distribution is a strength of the current WHO guidelines for aerobic exercise prescription; however, we believe that incorporating other simple and practical tools available to the general population for monitoring intensity, such as the TT, is warranted, as it provides greater specificity for aerobic exercise testing and prescription by professionals. In addition, we suggest incorporating the TID model used by athletes for aerobic exercise programming in the general population and physically inactive subjects, which typically involves continuous (Z1 and Z2) and interval (Z2 and Z3) aerobic exercise.[21 32 33] From a practical perspective, people should first determine their aerobic training zones using the RPE scale and/or the TT and then translate this information to an aerobic exercise programme according to the goal of the TID model. For instance, if a person wants to exercise at low-intensity (Z1), they should feel ~3 on the RPE scale of 0–10 and/or be able to sing their favourite song; likewise, an RPE value >4 and/or not being able to sing their favourite song is a good indicator that a person is exercising at moderate-intensity to high-intensity (Z2 and Z3). According to the typical TID of athletes, improvements are observed after 6–8 weeks,[39 40] therefore, we suggest testing with a similar periodicity. Figure 1 shows our approach to the continuum between aerobic exercise testing and prescription concerning these simple and practical tools.

## RESISTANCE EXERCISE

### Testing and prescription

The WHO 2020 guidelines have emphasised the importance of strengthening or resistance exercise (RE) for enhancing overall health. However, the recommendation may be too broad when transferring this to testing and prescription. It only proposes that 'additional health benefits will occur through participation in muscle-strengthening activities at moderate or greater intensity on two or more days a week'. Typically, the objectives and methodology of RE have been associated with neural and morphological effects,[41] where the prescription of RE intensities is strictly linked to the load in relative terms.[42] However, from a contemporary view, the ultimate goal of a resistance training programme is to improve the maximal force production applied against a specific absolute load(s) (mass).[43 44] Regardless, it is essential to determine the magnitude of the external or absolute load before prescribing RE. The most traditional way to assess dynamic strength, although stressful and more

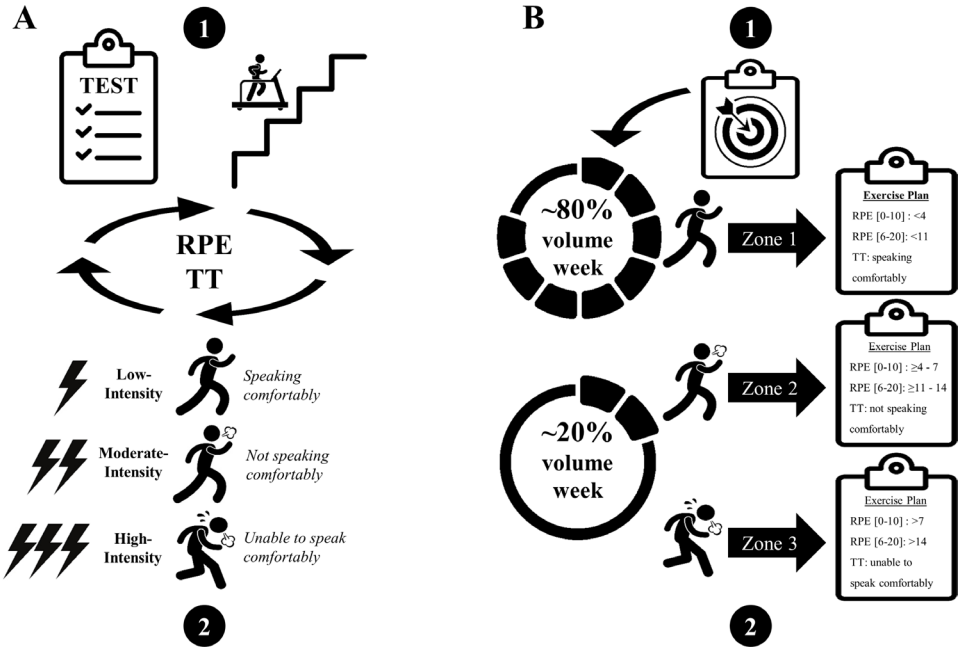


**Figure 1** General diagram for testing and prescribing an aerobic exercise programme for the general population. (A) The diagnosis (test) of the current state (1) is the first step for the prescription of aerobic exercise by training zones based on simple and practical tools (2). (B) After determining the training goal (1), the training intensity distribution is applied under the pyramidal (zone 1>zone 2>zone 3) or polarised (zone 1>zone 3>zone 2) model format (2). For further details, refer to the text. LT, lactate threshold; RPE, rating scale of perceived exertion; RPE 0–10, rating scale of perceived exertion from 0 to 10; RPE 6–20, rating scale of perceived exertion from 6 to 20; TT, Talk Test; VT, ventilatory threshold; zone 1, exercise intensity <LT1/VT1; zone 2, exercise intensity ≥LT1/VT1 up to ≤LT2/VT2; zone 3, exercise intensity >LT2/VT2.

likely to cause injury, is by setting how much weight an individual can lift for one-repetition maximum (ie, 1RM),[45] where the most used indicator of intensity for RE prescription is the percentage associated with the 1RM (ie, %1RM).[46] However, a safer and popular way to assess strength is by using submaximal loads and counting the number of repetitions to fatigue (ie, nRM), relating this to a %1RM.[45] Although these procedures are simple and practical, they have their limitations. For instance, to achieve a true 1RM, traditional multi-joint strength exercises must reach a specific movement velocity (MV) that characterises them,[47–49] so if this is not achieved, it is not possible to speak of a true 1RM. Regarding the nRM, the number of repetitions performed between 50% and 85% 1RM shows a large inter-individual variability (~20%) with bench press exercise,[50] so if two individuals train with the same number of maximum repetitions, they may be training at a different %1RM. That being said, the nRM test can be used as a practical tool to individually determine an absolute load (kg) for RE prescription, as recently reported in older adults and master athletes.[51] Furthermore, as moderate-load multi-joint REs of the upper and lower limbs (ie, 65%–75% 1RM) have a range of ~10 to 20 nRM,[52] we suggest using the nRM within the 10–20 repetition range to assess moderate loads (kg), where a higher or lower nRM will robustly represent light and heavy loads, respectively.

Recent evidence has reported that traditional multi-joint strength exercises have a very high relationship between MV and %1RM,[47–49] allowing with few submaximal loads to estimate 1RM, reducing the risk of injury and the variability of applying nRM. Furthermore, control of MV allows assessing the velocity loss (VL), with the latter being associated with the level of effort (LoE) in relation to the repetitions in reserve (RIR) and to the percentage of repetitions performed for the maximum possible (%rep).[52] Therefore, monitoring MV and VL during RE allows a precise knowledge of %1RM without the need to perform any 1RM or nRM test[43] and to quantify neuromuscular fatigue objectively.[53] However, measuring MV and VL requires specialised instruments (ie, transducers or validated mobile applications); therefore, we again propose using the RPE scale, as it validly measures exercise intensity and physiological exertion during RE.[54 55] For example, the RPE (0–10 scale) in experienced and novice subjects has been reported to be a valid indicator for estimating %1RM and RIR at moderate-loads to high-loads, where an RPE of 1–2, 5–6 or 10, represented little to no effort, more repetitions can be performed or no more repetitions (max effort), respectively.[56] Besides the RPE, the LoE approach, which is the relationship between the number of repetitions that are done in a set and those that could be done[53] can also be used for prescribing RE. Interestingly, the LoE approach can be applied with traditional multi-joint exercises, relative intensities and in subjects with different strength levels.[52]

In an integrative and practical way, despite nRM (ie, exercise to failure) being suboptimal for RE prescription,[57 58] it can be applied as a simple test to assess dynamic strength at moderate to heavy loads.[51] Therefore, if a subject performs ~16 nRM at a specific absolute load (kg) and plans to train at a low to moderate LoE, it would be recommended to prescribe ≤8 repetitions (ie, 5–8 (16)) with an RPE value of 5–6 (0–10 scale). As a general rule, 3–4 sets should be performed with 2–4 min of intra-set recovery.[49 59]

## Programming

Concerning RE programming, the WHO 2020 guidelines, as stated before, only refer to performing two or more days per week of muscle-strengthening activities. Again, although this approach has solid evidence,[60] we consider it too general for RE programming. Greater upper-body and lower-body muscular strength levels are associated with a lower mortality risk in the adult population.[61] Furthermore, greater muscular strength is associated with enhanced force-time characteristics, general and specific sport skill performance, enhanced potentiation effects and decreased injury rates.[62] Just as athletes may have specific strength requirements,[63] physically inactive or untrained subjects can also benefit from RE in its different manifestations (ie, light, moderate and heavy loads) according to their daily tasks and needs (work, leisure, housework, etc). For instance, a recent within-subject study in older adults observed that heavy loads were more appropriate for developing high-force capabilities. In contrast, using light loads was superior in promoting rate of force development, even though both protocols led to similar gains in power and muscle size.[64] These results imply that it is possible to choose a variety of intensities for RE programming, which not only yield different adaptations but could positively affect participant enjoyment and adherence, avoiding training monotony.

Again, we want to highlight the role of VL and RPE for optimal RE programming. Low to moderate VL thresholds (≤25%) are superior for promoting strength, possibly by minimising acute neuromuscular fatigue while maximising chronic neuromuscular adaptations, whereas moderate to high VL thresholds (>20%–25%) are superior for promoting hypertrophy.[65] These VL-based effects have been evidenced with upper and lower multi-joint exercises using moderate to heavy loads in healthy young adults[66 67] and moderate loads in older adults.[68] Recently Varela-Olalla *et al* found a high positive relationship between %rep and RPE and VL, where >50% rep was associated with >6 RPE (0–10 scale) and with >30% VL during the concentric action at the maximum possible velocity of a moderate to heavy load bench press exercise, allowing to quantify the LoE objectively.[69] Similar results were found using the RIR-based RPE approach during heavy-load lower limb exercises.[70] Although caution should be taken when relationships are considered, RPE is a valuable tool for estimating the LoE without having to measure MV, where the higher the RPE, the greater the LoE (ie, VL, %rep and RIR), independent of %1RM.

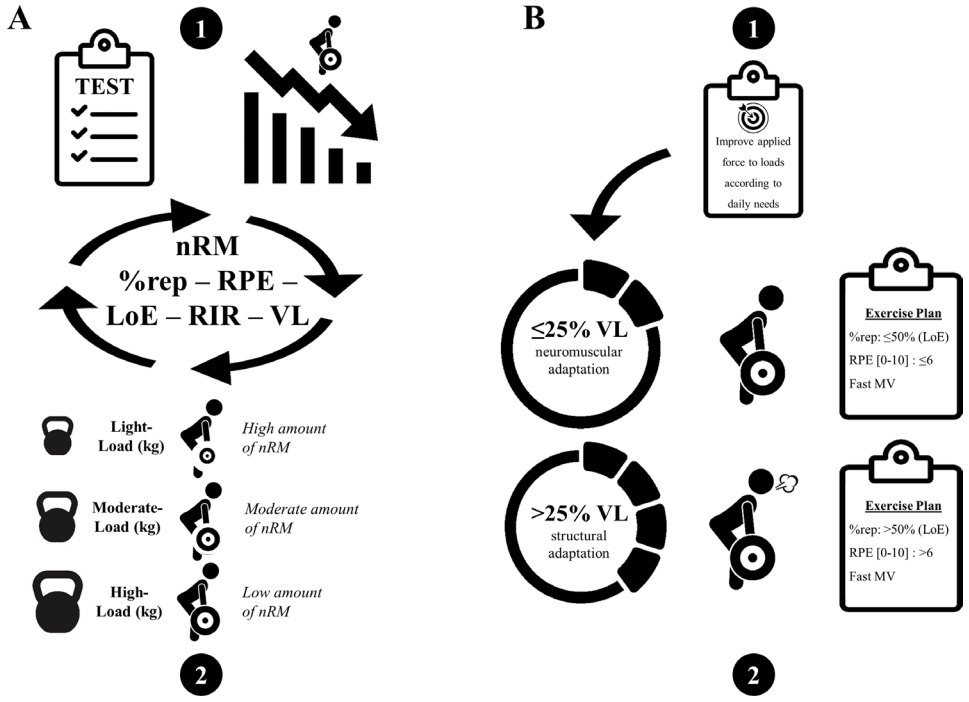


**Figure 2** General diagram for testing and prescribing a resistance exercise programme for the general population. (A) The diagnosis (test) of the current state (1) is the first step for the prescription of resistance exercise through percentages of repetitions with respect to the maximum possible (ie, nRM) to then determine the intra-set velocity loss at different external loads (kg) based on simple and practical tools (2). (B) Once the training goal has been established (1), the intra-set velocity loss is planned through the percentage of repetitions with respect to the maximum possible and the rating scale of perceived exertion (RPE) (2). For further details, refer to the text. Fast MV, fast movement velocity (concentric phase); LoE, level of effort; nRM, repetitions with respect to the maximum possible; %rep, percentage of repetitions with respect to the maximum possible; RPE, rating scale of perceived exertion; RPE 0–10, rating scale of perceived exertion from 0 to 10; RIR, repetitions in reserve; VL, velocity loss.

A relevant aspect to optimise RE adaptations is the concentric velocity at which the load is lifted. Repetitions performed at maximal intended velocity during the concentric phase have a more beneficial effect on dynamic neuromuscular performance than those performed at an intentionally slower half-velocity.[71] Therefore, we suggest that the concentric phase of each exercise should be performed at the fastest possible velocity, according to the individual capacity. Thus, to achieve the maximum possible velocity against a specific absolute load, the applied force must be the maximum that the subject can exert against that particular load.[43] However, we understand that for learning reasons, subjects could be asked to perform at a controlled velocity during the programme's initial phase. In this case, the use of RPE to control the LoE can also be extended to multi-joint[72] and single-joint[73] exercises performed at a controlled velocity.

Finally, we know that not everyone has access to training centres. In this context, it is interesting to highlight that public OFEs (ie, rowing machine; bonny rider) are also effective for the improvement of muscle strength[18]; where low, moderate and high RPE values are achieved by manipulating the cadence of movement[19] and consequently regulating the LoE. Furthermore, the RPE scale has been used to determine the stress imposed on all-out body-weight (ie, callisthenics) and elastic band (grip-related tension) exercises.[74 75] This last element suggests an exciting alternative for subjects with muscular weakness or sarcopenia. In this regard, Colado *et al* have validated an OMNI-Resistance Exercise Scale (0–10; extremely easy to extremely hard) with elastic band RE in older adults.[75] However, despite the attractiveness of these tools, it is essential to point out the difficulty of determining the force manifestations (light, moderate and heavy loads) with them, where a velocity-effort (eg, load, %RM) relationship might not be the primary RT training goal.[44]

In summary, although nRM is not an optimal training methodology, it is a simple and practical individual testing tool for muscle-strengthening exercises and is within reach of the general population. For the prescription and programming of RE, the VL estimated through RPE and %rep (or LoE, RIR) allows to project the desired effects of the training programme. From a practical perspective, once the muscle-strengthening exercises are chosen, the subject can determine the absolute load (kg) through nRM testing and prescribe each exercise considering the RPE scale and/or the %rep (or LoE, RIR). This information is then transferred to an RE programme based on the daily force application needs (ie, light, moderate or heavy load). Thus, if a subject performs ~10 nRM (ie, moderate load) of a strength exercise and wants to

maximise neuromuscular adaptations, he/she could prescribe ≤5 repetitions (ie, 3–5 (10)) at a fast concentric velocity reaching low to moderate RPE values (ie, ≤6 RPE; 0–10 scale). On the other hand, if the goal of the person is to maximise structural adaptations (ie, hypertrophy) at the same moderate load, >6 repetitions (ie, 8–9 (10)) should be performed, reaching moderate to high RPE values and %rep (high LoE; lower RIR) (ie, ~8+ RPE; 0–10 scale). According to previous studies,[49 59] we suggest 3–4 sets with 2–4 min of recovery between them. In agreement with the observed changes in the load–velocity relationship,[66 71] we suggest to adjust the load every 6–8 weeks by performing a new nRM test. Although with certain limitations, this approach can also be applied with OFE, body-weight (callisthenics) and elastic band exercises. Figure 2 summarises our approach regarding RE programming based on VL with simple and practical tools (ie, RPE and %rep) depending on the objectives pursued.

## Conclusions and perspectives

In the present article, we propose that current reference guidelines on PA for the general population from the WHO may be moved forward by adding specific recommendations for exercise prescription in apparently healthy individuals or those with different health conditions. The research in the field of PA during the last decades has set an opportunity for providing overall recommendations based on high-quality evidence. Further efforts should focus on providing complementary and more specific recommendations. In the meantime, we propose a methodology in which the prescription of aerobic exercise should be based on individualised metabolic disturbances and the TID model used by endurance athletes. For RE prescription, we suggest that loads based on MV associated with VL are a more reliable approach than a fixed set number of repetitions. In both cases, the RPE scale can be a useful and valid tool for aerobic and RE testing and prescription. In addition, for aerobic exercise prescription, the TT could be added to provide additional support. These simple tools will allow the general population to be educated about their fitness level and self-management of exercise intensity, and aid professionals, clinicians and primary care providers to optimise exercise programmes for improvement of fitness status, and exercise adherence without the need for specialised equipment and measurements. To improve the specificity of exercise adaptation, future research should focus on further developing training programme components for the general population, such as exercise frequency, intensity, time and type (ie, the FITT principle).

**Author affiliations**
[1]Sports Performance Research, Rosario, Argentina
[2]Instituto de Ciencias de la Salud, Universidad de O'Higgins, Rancagua, Chile
[3]Interuniversity Center for Healthy Aging RED21993, Santiago, Chile
[4]Geroscience Center for Brain Health and Metabolism (GERO), Santiago, Chile
[5]Exercise and Rehabilitation Sciences Institute, Faculty of Rehabilitation Sciences, Universidad Andrés Bello, Santiago, Chile
[6]Departamento de Ciencias de la Rehabilitación, Facultad de Medicina, Universidad de La Frontera, Temuco, Chile
[7]Department of Physical Education, Sports and Recreation, Universidad de La Frontera, Temuco, Chile
[8]Health Department, Universidad de Los Lagos, Puerto Montt, Chile
[9]Research Group in Prevention and Health in Exercise and Sport, University of Valencia, Valencia, Spain
[10]Exercise Physiology and Metabolism Laboratory, Escuela de Kinesiología, Universidad Finis Terrae, Santiago, Chile
[11]Laboratorio de Actividad Física, Ejercicio y Salud, Centro de Biomedicina Aplicada, Universidad Mayor, Santiago, Chile
[12]Laboratory of Exercise Science, Innovation Center, Clinica MEDS, Las Condes, Chile
[13]Laboratory of Research in Nutrition and Physical Activity, Institute of Nutrition and Technology of Food, University of Chile, Santiago de Chile, Chile
[14]Núcleo de Investigación en Salud, Actividad Física y Deporte ISAFYD, Universidad de Las Americas, Viña del Mar, Chile
[15]Escuela de Medicina, Universidad de Magallanes, Punta Arenas, Chile
[16]Centro Asistencial Docente y de Investigación, Universidad de Magallanes, Punta Arenas, Chile

**Twitter** Raúl Ricardo Festa @rrfest

**Contributors** The idea of the manuscript was from SJ-V and RRF. RRF, EJ-S, DV-I, and SJ-V wrote the first draft of the manuscript. All authors have read, edited and contributed to the final version of the manuscript.

**Funding** This work has been funded by Interuniversity Center for Healthy Aging, Code RED21993, and by Fondecyt, Chile #11220033.

**Competing interests** None declared.

**Patient consent for publication** Not applicable.

**Ethics approval** Not applicable.

**Provenance and peer review** Not commissioned; externally peer reviewed.



**ORCID iDs**
Raúl Ricardo Festa http://orcid.org/0000-0003-4757-483X
Emilio Jofré-Saldía http://orcid.org/0000-0002-6726-9798
Alejandro A Candia http://orcid.org/0000-0002-1726-7559
Matías Monsalves-Álvarez http://orcid.org/0000-0003-3163-3911
Marcelo Flores-Opazo http://orcid.org/0000-0001-8743-1708
Luis Peñailillo http://orcid.org/0000-0001-7697-9700
Gabriel Nasri Marzuca-Nassr http://orcid.org/0000-0002-4835-7821
Nicolas Aguilar-Farias http://orcid.org/0000-0002-6974-1312
Nicole Fritz-Silva http://orcid.org/0000-0001-5248-7189
Jorge Cancino-Lopez http://orcid.org/0000-0003-3620-9861
Johana Soto-Sánchez http://orcid.org/0000-0001-6982-5447
Álvaro Huerta Ojeda http://orcid.org/0000-0001-6871-098X
Cristian Núñez-Espinosa http://orcid.org/0000-0002-9896-7062
Denisse Valladares-Ide http://orcid.org/0000-0001-7625-7978
Sebastian Jannas-Vela http://orcid.org/0000-0001-9619-592X

## REFERENCES

1 Bull FC, Al-Ansari SS, Biddle S, *et al*. World health organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med* 2020;54:1451–62.
2 Kohl HW 3rd, Craig CL, Lambert EV, *et al*. The pandemic of physical inactivity: global action for public health. *The Lancet* 2012;380:294–305.
3 Bennett JE, Stevens GA, Mathers CD, *et al*. NCD countdown 2030: worldwide trends in non-communicable disease mortality and

progress towards sustainable development goal target 3.4. *The Lancet* 2018;392:1072–88.
4 Carlson SA, Fulton JE, Pratt M, *et al*. Inadequate physical activity and health care expenditures in the United States. *Prog Cardiovasc Dis* 2015;57:315–23.
5 Santos AC, Willumsen J, Meheus F, *et al*. The cost of inaction on physical inactivity to public health-care systems: a population-attributable fraction analysis. *The Lancet Global Health* 2023;11:e32–9.
6 Lee I-M, Shiroma EJ, Lobelo F, *et al*. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet* 2012;380:219–29.
7 Katzmarzyk PT, Friedenreich C, Shiroma EJ, *et al*. Physical inactivity and non- communicable disease burden in low- income, middle- income and high- income countries. *Br J Sports Med* 2022;56:101–6.
8 Kerr NR, Booth FW. Contributions of physical inactivity and sedentary behavior to metabolic and endocrine diseases. *Trends Endocrinol Metab* 2022;33:817–27.
9 Verboven K, Hansen D. Critical reappraisal of the role and importance of exercise intervention in the treatment of obesity in adults. *Sports Med* 2021;51:379–89.
10 Baethge C, Goldbeck-Wood S, Mertens S. SANRA-a scale for the quality assessment of narrative review articles. *Res Integr Peer Rev* 2019;4:5.
11 Iannetta D, Keir DA, Fontana FY, *et al*. Evaluating the accuracy of using fixed ranges of Mets to categorize exertional intensity in a heterogeneous group of healthy individuals: implications for cardiorespiratory fitness and health outcomes. *Sports Med* 2021;51:2411–21.
12 Byrne NM, Hills AP, Hunter GR, *et al*. Metabolic equivalent: one size does not fit all. *J Appl Physiol (1985)* 2005;99:1112–9.
13 Gass GC, McLellan TM, Gass EM. Effects of prolonged exercise at a similar percentage of maximal oxygen consumption in trained and untrained subjects. *Eur J Appl Physiol Occup Physiol* 1991;63:430–5.
14 Baldwin J, Snow RJ, Febbraio MA. Effect of training status and relative exercise intensity on physiological responses in men. *Medicine & Science in Sports & Exercise* 2000;32:1648–54.
15 MacIntosh BR, Murias JM, Keir DA, *et al*. What is moderate to vigorous exercise intensity? *Front Physiol* 2021;12:682233.
16 Scherr J, Wolfarth B, Christle JW, *et al*. Associations between Borg's rating of perceived exertion and physiological measures of exercise intensity. *Eur J Appl Physiol* 2013;113:147–55.
17 Dantas JL, Doria C, Rossi H, *et al*. Determination of blood lactate training zone boundaries with rating of perceived exertion in runners. *J Strength Cond Res* 2015;29:315–20.
18 Chow H-W, Chang K-T, Fang I-Y. Evaluation of the effectiveness of outdoor fitness equipment intervention in achieving fitness goals for seniors. *IJERPH* 2021;18:12508.
19 Barbosa WA, Rica RL, Pontes Junior FL, *et al*. Psychophysiological effects of different execution speeds of single bout exercise in outdoor fitness equipment performed by older men. *Motriz: Rev Educ Fis* 2022;28:1–8.
20 Seiler S. What is best practice for training intensity and duration distribution in endurance athletes *Int J Sports Physiol Perform* 2010;5:276–91.
21 Seiler S, Tønnessen E. Intervals, thresholds, and long slow distance: the role of intensity and duration in endurance training. *Sportscience* 2009;13:32–53.
22 Gurovich AN, Heiser B, Hayes C, *et al*. Clinical markers of exercise intensity as a surrogate for blood lactate levels only during low-intensity exercise in patients with coronary artery disease. *Cardiopulm Phys Ther J* 2018;29:144–51.
23 U.S. Department of Health and Human Services. Physical activity guidelines for Americans. Washington, DC, U.S, 2018: 60.
24 Woltmann ML, Foster C, Porcari JP, *et al*. Evidence that the talk test can be used to regulate exercise intensity. *J Strength Cond Res* 2015;29:1248–54.
25 Dehart-Beverley M, Foster C, Porcari J, *et al*. Relationship between the talk test and ventilatory threshold. *Clin Exerc Physiol* 2000;2:34–8.
26 Sørensen L, Larsen KSR, Petersen AK. Validity of the talk test as a method to estimate ventilatory threshold and guide exercise intensity in cardiac patients. *J Cardiopulm Rehabil Prev* 2020;40:330–4.
27 Orizola-Cáceres I, Cerda-Kohler H, Burgos-Jara C, *et al*. Modified talk test: a randomized cross-over trial investigating the comparative utility of two 'talk tests' for determining aerobic training zones in overweight and obese patients. *Sports Med - Open* 2021;7:23.
28 Rodríguez-Marroyo JA, Villa JG, García-López J, *et al*. Relationship between the talk test and ventilatory thresholds in well-trained cyclists. *J Strength Cond Res* 2013;27:1942–9.
29 Bok D, Rakovac M, Foster C. An examination and critique of subjective methods to determine exercise intensity: the talk test, feeling scale, and rating of perceived exertion. *Sports Med* 2022;52:2085–109.
30 Clarke PM, Walter SJ, Hayen A, *et al*. Survival of the fittest: retrospective cohort study of the longevity of olympic medallists in the modern era. *BMJ* 2012;345:bmj.e8308.
31 Garatachea N, Santos-Lozano A, Sanchis-Gomar F, *et al*. Elite athletes live longer than the general population: a meta-analysis. *Mayo Clin Proc* 2014;89:S0025-6196(14)00519-9:1195–200.:.
32 Casado A, González-Mohíno F, González-Ravé JM, *et al*. Training periodization, methods, intensity distribution, and volume in highly trained and elite distance runners: a systematic review. *Int J Sports Physiol Perform* 2022;17:820–33.
33 Stöggl TL, Sperlich B. The training intensity distribution among well-trained and elite endurance athletes. *Front Physiol* 2015;6:295.
34 Pauw KD, Roelands B, Cheung SS, *et al*. Guidelines to classify subject groups in sport-science research. *International Journal of Sports Physiology and Performance* 2013;8:111–22.
35 Zapata-Lamana R, Henríquez-Olguín C, Burgos C, *et al*. Effects of polarized training on Cardiometabolic risk factors in young overweight and obese women: a randomized-controlled trial. *Front Physiol* 2018;9:1287:1287.:.
36 Wen CP, Wai JPM, Tsai MK, *et al*. Minimal amount of exercise to prolong life: to walk, to run, or just mix it up? *J Am Coll Cardiol* 2014;64:482–4.
37 Jaureguizar KV, Vicente-Campos D, Bautista LR, *et al*. Effect of high-intensity interval versus continuous exercise training on functional capacity and quality of life in patients with coronary artery disease: A RANDOMIZED CLINICAL TRIAL. *J Cardiopulm Rehabil Prev* 2016;36:96–105.
38 Festa RR, Monsalves-Álvarez M, Cancino J, *et al*. Prescription of high-intensity aerobic interval training based on oxygen uptake kinetics. *Int J Sports Med* 2023;44:159–68.
39 Filipas L, Bonato M, Gallo G, *et al*. Effects of 16 weeks of pyramidal and polarized training intensity distributions in well-trained endurance runners. *Scand J Med Sci Sports* 2022;32:498–511.
40 Neal CM, Hunter AM, Brennan L, *et al*. Six weeks of a polarized training-intensity distribution leads to greater physiological and performance adaptations than a threshold model in trained cyclists. *J Appl Physiol (1985)* 2013;114:461–71.
41 Aagaard P. Training-induced changes in neural function. *Exerc Sport Sci Rev* 2003;31:61–7.
42 American College of Sports Medicine. American college of sports medicine position stand. Progression models in resistance training for healthy adults.. *Med Sci Sports Exerc* 2009;41:687–708.
43 González-Badillo JJ, Sánchez-Medina L, Ribas-Serna J, *et al*. Toward a new paradigm in resistance training by means of velocity monitoring: a critical and challenging narrative. *Sports Med - Open* 2022;8:118.
44 Balsalobre-Fernández C, Torres-Ronda L. The implementation of velocity-based training paradigm for team sports: framework, technologies. *Sports* 2021;9:47.
45 Brzycki M. Strength testing—predicting a one-rep max from reps-to-fatigue. *Journal of Physical Education, Recreation & Dance* 1993;64:88–90.
46 Kraemer WJ, Ratamess NA. Fundamentals of resistance training: progression and exercise prescription. *Med Sci Sports Exerc* 2004;36:674–88.
47 Sánchez-Medina L, González-Badillo JJ, Pérez CE, *et al*. Velocity- and power-load relationships of the bench pull vs. bench press exercises. *Int J Sports Med* 2014;35:209–16.
48 Sánchez-Medina L, Pallarés J, Pérez C, *et al*. Estimation of relative load from bar velocity in the full back squat exercise. *Sport Med Int Open* 2017;1:80–8.
49 González-Badillo JJ, Sánchez-Medina L. Movement velocity as a measure of loading intensity in resistance training. *Int J Sports Med* 2010;31:347–52.
50 González-Badillo JJ, Yañez-García JM, Mora-Custodio R, *et al*. Velocity loss as a variable for monitoring resistance exercise. *Int J Sports Med* 2017;38:217–25.
51 Jofré-Saldía E, Villalobos-Gorigoitía Á, Gea-García G. Methodological proposal for strength and power training in older athletes: a narrative review. *Curr Aging Sci* 2022;15:135–46.
52 Hernández-Belmonte A, Courel-Ibáñez J, Conesa-Ros E, *et al*. Level of effort: a reliable and practical alternative to the velocity-based approach for monitoring resistance training. *J Strength Cond Res* 2022;36:2992–9.

53 Sánchez-medina L, González-badillo JJ. Velocity loss as an indicator of neuromuscular fatigue during resistance training. *Medicine & Science in Sports & Exercise* 2011;43:1725–34.
54 Lea JWD, O'Driscoll JM, Hulbert S, *et al*. Convergent validity of ratings of perceived exertion during resistance exercise in healthy participants: a systematic review and meta-analysis. *Sports Med - Open* 2022;8:2.
55 Buckley JP, Borg GAV. Borg's scales in strength training; from theory to practice in young and older adults. *Appl Physiol Nutr Metab* 2011;36:682–92.
56 Zourdos MC, Klemp A, Dolan C, *et al*. Novel resistance training-specific rating of perceived exertion scale measuring repetitions in reserve. *J Strength Cond Res* 2016;30:267–75.
57 Izquierdo-gabarren M, González De Txabarri Expósito R, García-pallarés J, *et al*. Concurrent endurance and strength training not to failure optimizes performance gains. *Medicine & Science in Sports & Exercise* 2010;42:1191–9.
58 Santos WDND, Vieira CA, Bottaro M, *et al*. Resistance training performed to failure or not to failure results in similar total volume, but with different fatigue and discomfort levels. *J Strength Cond Res* 2021;35:1372–9.
59 Pareja-Blanco F, Rodríguez-Rosell D, Sánchez-Medina L, *et al*. Effects of velocity loss during resistance training on athletic performance, strength gains and muscle adaptations. *Scand J Med Sci Sports* 2017;27:724–35.
60 Ralston GW, Kilgore L, Wyatt FB, *et al*. Weekly training frequency effects on strength gain: a meta-analysis. *Sports Med - Open* 2018;4:36.
61 García-Hermoso A, Cavero-Redondo I, Ramírez-Vélez R, *et al*. Muscular strength as a predictor of all-cause mortality in an apparently healthy population: a systematic review and meta-analysis of data from approximately 2 million men and women. *Arch Phys Med Rehabil* 2018;99:2100–13.
62 Suchomel TJ, Nimphius S, Stone MH. The importance of muscular strength in athletic performance. *Sports Med* 2016;46:1419–49.
63 Nader GA. Concurrent strength and endurance training: from molecules to man. *Med Sci Sports Exerc* 2006;38:1965–70.
64 Rodriguez-Lopez C, Alcazar J, Sanchez-Martin C, *et al*. Neuromuscular adaptations after 12 weeks of Light- vs. heavy-load power-oriented resistance training in older adults. *Scand J Med Sci Sports* 2022;32:324–37.
65 Hickmott LM, Chilibeck PD, Shaw KA, *et al*. The effect of load and volume Autoregulation on muscular strength and hypertrophy: A systematic review and meta-analysis. *Sports Med - Open* 2022;8:9.
66 Rodiles-Guerrero L, Cornejo-Daza PJ, Sánchez-Valdepeñas J, *et al*. Specific adaptations to 0%, 15%, 25%, and 50% velocity-loss thresholds during bench press training. *International Journal of Sports Physiology and Performance* 2022;17:1231–41.
67 Pareja-Blanco F, Alcazar J, Sánchez-Valdepeñas J, *et al*. Velocity loss as a critical variable determining the adaptations to strength training. *Med Sci Sports Exerc* 2020;52:1752–62.
68 Marques DL, Neiva HP, Marinho DA, *et al*. Novel resistance training approach to monitoring the volume in older adults: the role of movement velocity. *Int J Environ Res Public Health* 2020;17:7557.
69 Varela-Olalla D, del Campo-Vecino J, Leyton-Román M, *et al*. Rating of perceived exertion and velocity loss as variables for controlling the level of effort in the bench press exercise. *Sports Biomechanics* 2022;21:41–55.
70 Odgers JB, Zourdos MC, Helms ER, *et al*. Rating of perceived exertion and velocity relationships among trained males and females in the front squat and hexagonal bar deadlift. *J Strength Cond Res* 2021;35(Suppl 1):S23–30.
71 Pareja-Blanco F, Rodríguez-Rosell D, Sánchez-Medina L, *et al*. Effect of movement velocity during resistance training on neuromuscular performance. *Int J Sports Med* 2014;35:916–24.
72 Zhao H, Seo D, Okada J. Validity of using perceived exertion to assess muscle fatigue during back squat exercise. *BMC Sports Sci Med Rehabil* 2023;15:14.
73 Zhao H, Nishioka T, Okada J. Validity of using perceived exertion to assess muscle fatigue during resistance exercises. *PeerJ* 2022;10:e13019.
74 Bellissimo GF, Ducharme J, Mang Z, *et al*. The acute physiological and perceptual responses between bodyweight and treadmill running high-intensity interval exercises. *Front Physiol* 2022;13:824154.
75 Colado JC, Pedrosa FM, Juesas A, *et al*. Concurrent validation of the OMNI-resistance exercise scale of perceived exertion with elastic bands in the elderly. *Exp Gerontol* 2018;103:11–6.