Journal of Iranian Medical Council, Volume 8, Issue no. 3
http://dx.doi.org/10.18502/jimc.v8i3.18791

Review Article

National Research Institute of Tuberculosis and Lung Disease (NRITLD) Implementation Protocol of an Exercise Training Program in Pulmonary Rehabilitation of Patients with COPD

Mohsen Abedi[1,2], Abouzar Mojibian[1], Masoumeh Zoghali[1,3], Seyed Bashir Mirtajani[4]*, Malika Valizadeh[1], Reyhaneh Zahiri[1] and Maryam Sadat Mirenayat[1]*

1. Pulmonary Rehabilitation Research Center (PRRC), National Research Institute of Tuberculosis and Lung Diseases (NRITLD), Shahid Beheshti University of Medical Sciences, Tehran, Iran
2. Physiotherapy Research Center, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran
3. Physical Medicine & Rehabilitation Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran
4. Lung Transplantation Research Center, National Research Institute of Tuberculosis and Lung Diseases (NRITLD), Shahid Beheshti University of Medical Sciences, Tehran, Iran

Abstract

Pulmonary rehabilitation is an effective method to improve the clinical conditions of patients with Chronic Obstructive Pulmonary Disease (COPD), which includes providing a supervised exercise program at home or in a treatment center according to the patient's conditions and abilities. Despite the many benefits of pulmonary rehabilitation, it has not received much attention in different countries. Pulmonary rehabilitation is done according to international general guidelines, but it is very important to develop center-based programs according to existing facilities and conditions. Currently, very few pulmonary rehabilitation centers are active in Iran. Considering the limitations in access to patients, and the importance of pulmonary rehabilitation in the treatment process of patients with COPD, in the present study, the pulmonary rehabilitation protocol, localized by National Research Institute of Tuberculosis and Lung Disease (NRITLD) in Tehran, Iran, has been presented.

Keywords: Attention, Chronic obstructive, Exercise therapy, Humans, Iran, Pulmonary disease, Rehabilitation centers, Tuberculosis

*** Corresponding authors**

Seyed Bashir Mirtajani, PhD
Lung Transplantation Research Center, National Research Institute of Tuberculosis and Lung Diseases (NRITLD), Shahid Beheshti University of Medical Sciences, Tehran, Iran
Tel: +98 9377789931
Email: b.mirtajani@theaasm.org

Maryam Sadat Mirenayat, MD
Pulmonary Rehabilitation Research Center (PRRC), National Research Institute of Tuberculosis and Lung Diseases (NRITLD), Shahid Beheshti University of Medical Sciences, Tehran, Iran
Tel: +98 21 2610 9991
Email: MirenayaT_M@yahoo.com

Received: 7 Apr 2024
Accepted: 9 Sept 2024

Citation to this article
Abedi M, Mojibian A, Zoghali M, Mirtajani SB, Zahiri R, Mirenayat MS. National Research Institute of Tuberculosis and Lung Disease (NRITLD) Implementation Protocol of an Exercise Training Program in Pulmonary Rehabilitation of Patients with COPD. *J Iran Med Counc*. 2025; 8(3):477-84.

Introduction

An overview of what is common in the world

Various conventional methods for exercise training of patients with Chronic Obstructive Pulmonary Disease (COPD) who participate in pulmonary rehabilitation programs mainly include endurance training (continuous or intermittent) and strength training.

Endurance training

Endurance training is the most common exercise method in patients with COPD. The main goal of endurance training is to improve aerobic exercise capacity, since aerobic activities are part of many daily tasks in these patients. Endurance training has also been shown to improve peripheral muscle function in patients with COPD (1). In addition, there is evidence that high-intensity endurance exercise produces greater physiological benefits than lower-intensity exercise (2). However, most patients with severe COPD are unable to continue high-intensity exercise due to serious symptoms such as dyspnea and fatigue (3). Therefore, alternative exercise protocols, such as interval training, have received increasing attention, especially in patients with advanced COPD.

Continuous training versus intermittent training

Historically, interval training involves the ability of high-intensity exercise on the peripheral muscles without putting too much strain on the cardiorespiratory system. As previously mentioned, people with COPD have a different response to exercise compared to healthy people due to the factors that limit physical activity.

A systematic review including eight randomized controlled trials with 388 COPD patients compared the effects of continuous and intermittent exercise (4). It was found that both methods led to comparable improvements in exercise capacity and health-related quality of life. However, in patients with very severe COPD, there is evidence that interval training is associated with fewer symptoms of dyspnea during exercise and fewer unwanted interruptions (5-7).

Interval training consists of a sequence of pressures applied to the muscles alternately (on and off), however, it has been revealed that it is easier to tolerate for the respiratory and peripheral muscles than training with a constant load (9).

In general, many patients suffer from physical limitations in daily life. To avoid patients' disappointment in doing sports exercises, providing specific exercise protocols for each patient can help in this field. It seems that this can improve patients' motivation and in some cases increase long-term adherence to exercise programs. However, in patients with COPD, especially older people, patients should familiarize themselves with the state of exercises and rest intervals first so that they can follow the proper order of work and rest intervals for the required period.

An easy approach to target training intensity for continuous training [60%: Peak Work Rate (PWR)] and interval endurance training (80% PWR) on the bicycle is to derive the training intensity from a certain percentage of peak workload. For more effective and feasible cycling load adjustment, patients' modified Borg scale (0-10) should be between 4 and 6. Table 1 shows some practical recommendations for implementing continuous and interval endurance training programs.

Table 2 shows the parameters that determine when to use the interval training protocol. If the patient is borderline at some of these points, it is recommended that the patient be allowed to decide which exercise protocol they prefer. The patient can try both methods in the first days of the pulmonary rehabilitation program and share his opinion. Using patients' opinions in planning the exercise program can improve their willingness to adhere to the intervention.

Oxygen supplement consumption during exercise

The benefits of Long-Term Oxygen Therapy (LTOT) in patients with COPD associated with hypoxemia are well known. In these patients, LTOT prolongs survival and reduces hospitalization as well as the risk of comorbidities (18,19). Recently, the usefulness of oxygen therapy in improving pulmonary rehabilitation outcomes in patients with COPD has been evaluated in several studies. Supplemental oxygen therapy has been studied in patients who are severely hypoxemic at rest or with exercise as an adjunct to exercise training. The rationale of these studies is that supplemental oxygen therapy improves

Table 1. Practical recommendations for the implementation of continuous and periodic endurance training programs

	Continuous endurance training	Interval endurance training
Frequency	All days of the week	All days of the week
Moderate	Continuous	Interval Modes: 30 *s* exercise, 30 *s* rest 20 *s* exercise, 40 *s* rest
Intensity	-Initially with 60-70% PWR -Increase workload with 5-10% tolerance - Advance training and effort until reaching ~ 80-90% of initial power	-Start with 80-100% PWR for the third or fourth session -Increased workload up to 5-10% tolerance - Advance until reaching ~ 150% of initial power
Duration	- Start with 10-15 *min* for the first 3 or 4 sessions - Advancing exercises by increasing the duration of 30-40 *min*	- Start with 15-20 *min* for the first three or four sessions - Advancement of exercises by increasing the duration up to 15-60 *min* (with rest time)
Perceived exertion	Trying to maintain Borg scale 4 to 6	Trying to maintain Borg scale 4 to 6
Breathing technique	Suggest breathing with pursed lips or using PEP devices to prevent dynamic hyper infiltration and reduce breathing frequency	Suggest breathing with pursed lips or using PEP devices to prevent dynamic hyper infiltration and reduce breathing frequency

PWR: Peak Work Rate, PEP: Positive Expiratory Pressure.

Table 2. Practical indications for considering the use of interval training approach

Interval training may be more appropriate when the patient presents with:
Severe airflow obstruction (FEV1 <40% pred)
Low training capacity (peak work rate <60% pred)
Total time in a constant work rate test <10 *min*
Significant oxygen desaturation during exercise (SpO_2 <85%)
Unbearable dyspnea during sustained endurance exercise

FEV1: Forced Expiratory Volume in the first second.

peripheral muscle oxygenation (20), dyspnea (21), and exercise capacity (22) in patients with COPD and hypoxemia, possibly allowing them to exercise at a higher intensity. The oxygen saturation level measured by pulse oximeter should be more than 90% or arterial oxygen pressure should be more than 55 *mmHg* (24).

Strength training

Peripheral muscle dysfunction and muscle weakness are among the most common comorbidities in COPD patients that lead to exercise intolerance and worsening symptoms (26,27). It is hypothesized that resistance training can reverse peripheral muscle dysfunction and thereby, at least partially, reduce the burden of COPD (28). Resistance training is recommended as an adjunct to improve endurance in all patients, especially those with peripheral muscle weakness. Considering that strength training has a greater potential to improve muscle mass and strength than endurance training (29,30), a combination of these two exercise methods is highly recommended. Strength training also produces less dyspnea during exercise, likely making it easier to tolerate than aerobic exercise (31).

A systematic review that included 18 randomized controlled trials demonstrated consistent improvements in muscle strength despite wide variation in training characteristics, such as the number of repetitions, training intensity, or the strength training method itself (32). Another important and clinically relevant finding of this article was that the effects of strength training can lead to significant changes in the patient's functional activities such as climbing stairs or lifting objects (32).

Table 3 lists the parameters related to strength training (33). The principle of deriving strength training intensity from 1RM (repetition maximum) should be carefully considered. Due to the large inter-individual variability and the wide range of variation in the number of repetitions possible at a given percentage

Table 3. Practical recommendations for performing the strength training

Frequency	2-3 days per week
Purpose	Targeting localized muscle fatigue at a specified number of repetitions for major muscle groups of the upper and lower limbs
Moderate	2-4 sets of 6-12 repetitions
Intensity	50-85% of one repetition maximum as a reference point, if possible one to two repetitions more than desired in two consecutive training sessions, increase the workload by 2-10%
Speed	Medium (1-2 *s* concentric and 1-2 *s* eccentric)

of 1RM, the degree of muscle fatigue was considered carefully for more precision in achieving the intensity of strength training (34,35). Therefore, the main focus can be on targeting local muscle fatigue in the 6-12 repetition range (or setting a 6-12 repetition maximum). An easy and very practical way to determine the optimal resistance for strength training is for the physiotherapist to set the training load based on 1RM so that the patient can repeat an exercise six to a maximum of 12 times before stopping due to muscle fatigue. When the subject can perform the current workload for one or two more repetitions than the desired number of six to 12 repetitions in two consecutive training sessions, it is recommended to apply a 2 to 10% increase in load (36).

Pulmonary rehabilitation at Masih Daneshvari Hospital

The pulmonary rehabilitation team of Masih Daneshvari Hospital, Tehran, Iran, consisting of pulmonary therapists, physical medicine, physiotherapists, and nurses, has been working as the first pulmonary rehabilitation center in Iran for nearly 10 years. Therefore, based on the results of treatment experiences, while modeling the international trend, they have taken a kind of localization of the rehabilitation protocol for patients with COPD, which is optimized and implemented according to the conditions governing the treatment team and the clinical condition of the patients.

One of the unique features of lung rehabilitation in this hospital is the presence of an inpatient ward for lung rehabilitation. Chronic respiratory patients who need medical services, oxygen therapy, physiotherapy, and non-invasive ventilation are admitted to this department and receive these medical services on a regular basis. Generally, as soon as patients are admitted to the ward, they are visited by a pulmonologist and receive the necessary prescriptions for medication, oxygen therapy, and non-invasive ventilation. Then, if the patients reach a stable condition and have no acute condition (exacerbation), they are evaluated by a specialist physician. These evaluations include the following:

Investigating contraindications for physical therapy and exercise therapy, such as thrombosis, embolism, orthopedic or neurological problems, *etc*.

Examining the patient's conditions in terms of the amount of oxygen needed in two states of rest and activity

Examining the patient's conditions in terms of the need for airway clearing techniques

Examining the conditions of the patient's breathing patterns and the function of the respiratory muscles

Examining the strength of the muscles of the lower limb (quadriceps muscle) and upper limb (grip strength of the hands)

Also, in order to check the effect of rehabilitation exercises, the following indicators are used:

The 6 Minute Walk Test (6MWT)

Sit to stand

modified Medical Research Council (mMRC)

The COPD Assessment Test (CAT)

St. George's Questionnaire

After performing the initial evaluations and recording the results of the tests, the lung rehabilitation programs are implemented by the physiotherapist in the following order:

Implementation of airway clearance techniques of necessary and needed by the patient

Teaching correct breathing patterns, including diaphragmatic breathing, pursed lip breathing, chest

expansion exercises, not using respiratory muscles, and teaching methods to overcome dyspnea.

Performing strength exercises according to the patient's condition on the bed

Lowering the patient from the bed and performing balance exercises according to the patient's condition

Referring the patient to a special hall for aerobic and resistance exercises

How to exercise in a special hall

At first, the method and purpose of exercise are explained to the patient by the physiotherapist, and aerobic exercise begins by using a stationary bike. In patients who have the condition to use a treadmill, exercise on a stationary bike is considered as a warm-up phase (for a maximum of 10 *min*) and then the main aerobic exercise begins on the treadmill. If the patients are unable to use a treadmill due to orthopedic problems or severe weakness, they use a stationary bike for 10 to 15 *min* with 1-2 load. If the patient's conditions are suitable for using the treadmill, the procedure is as follows:

- Initial warm-up using a stationary bike for 5 to 10 *min*
- Performing pulse oximetry of the patient to check the need for oxygen therapy and the amount of oxygen flow
- Starting walking on the treadmill at a speed of 1 *km/hr*
- Increasing the speed according to the intensity obtained from the 6-*min* walking test

To determine the intensity of exercise based on the 6-*min* walking test, the distance obtained in this test is converted into kilometers per hour, and then 80% of it is used to start training on the treadmill.

- Exercise for 10 to 20 *min* according to the patient's tolerance
- Gradual return to a speed of 1 *km/h* in the last 2 *min* as a cooling phase
- Doing stretching exercises on the upper and lower limbs after finishing the treadmill

All the steps of the above exercises are performed for patients 6 days a week. Usually, on 3 days out of these 6 days, resistance exercises including the use of elastic bands (any type) and light dumbbells are also performed in the gym for patients.

Normally, patients are hospitalized for an average of two weeks, and at the time of discharge, the indicators of lung rehabilitation are measured and recorded again. At the time of discharge, the required educational pamphlets are provided to the patients (Figure 1). The main differences between the pulmonary rehabilitation method in the rehabilitation department of Masih Daneshvari Hospital and the common international protocol are presented in table 4.

Conclusion

Pulmonary rehabilitation is one of the treatment lines of COPD, the most important part of which is providing exercise training. Novel and localized models of pulmonary rehabilitation help to optimally use local resources, strengthen the health system, and improve pulmonary rehabilitation outcomes. Considering the quality of pulmonary rehabilitation programs and providing suitable suggestions for when

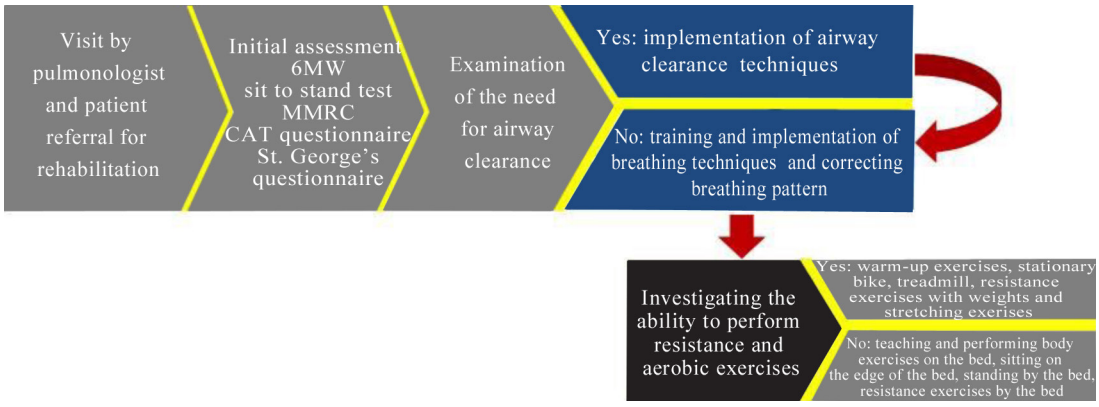

Figure 1. The steps of pulmonary rehabilitation in the pulmonary rehabilitation department of Masih Daneshvari Hospital.

Table 4. The difference between National institute of tuberculosis and lung disease of Masih Daneshvari Hospital pulmonary rehabilitation protocol and the international protocol

	Type of patient	The duration of rehabilitation	Number of rehabilitation sessions per week	Exercise intensity	Duration of each training session	Type of rehabilitation exercises
NRITLD protocol	Inpatients	≥2 weeks	6 times	80% of the 6MWT test	10 to 40 *min*	Treadmill, bicycle, walking, strength exercises, stretching, dumbbells, exercise stretch, breathing exercises
Common protocol	Outpatient	≥4 weeks	3 times	60-70% PWR	15 to 60 *min*	Treadmill, bicycle, strength training

NRITLD: National Institute of Tuberculosis and Lung Disease, 6MWT: Six Minute Walk Test, PWR: Peak Work Rate

and how to perform exercises plays a significant role in the progress of pulmonary rehabilitation programs.

Acknowledgement

The current study was registered with ethics code IR.SBMU.NRITLD.REC.1402.139 by the ethics committee of Pulmonary Rehabilitation Research Center, Masih Daneshvari Hospital, Tehran, Iran.

Conflict of Interest

Authors declare no conflict of interest.

References

1. Vogiatzis I, Terzis G, Nanas S, Stratakos G, Simoes DC, Georgiadou O, et al. Skeletal muscle adaptations to interval training in patients with advanced COPD. Chest 2005;128: 3838-45.

2. Casaburi R, Porszasz J, Burns MR, Carithers ER, Chang RS, Cooper CB. Physiologic benefits of exercise training in rehabilitation of patients with severe chronic obstructive pulmonary disease. Am J Respir Crit Care Med 1997;155:1541-51.

3. Abaei E, Abedi M, Sadat Mirenayat M, Rezaee M. The effect of high-intensity interval training in people with respiratory disease: a review study. Sci J Rehabilit Med 2023 Mar 21;12(1):18-29.

4. Beauchamp MK, Nonoyama M, Goldstein RS, Hill K, Dolmage TE, Mathur S, et al. Interval versus continuous training in individuals with chronic obstructive pulmonary disease – a systematic review. Thorax 2010;65:157-64.

5. Vogiatzis I, Terzis G, Stratakos G, Cherouveim E, Athanasopoulos D, Spetsioti S, et al. Effect of pulmonary rehabilitation on peripheral muscle fiber remodeling in patients with COPD in GOLD stages II to IV. Chest 2011;140:744-52.

6. Puhan MA, Busching G, Schunemann HJ, VanOort E, Zaugg C, Frey M. Interval versus continuous high-intensity exercise in chronic obstructive pulmonary disease: a randomized trial. Ann Intern Med 2006;145:816-25.

7. Gloeckl R, Halle M, Kenn K. Interval versus continuous training in lung transplant candidates: a randomized trial. J Heart Lung Transplant 2012;31:934-41.

8. Vogiatzis I, Nanas S, Kastanakis E, Georgiadou O, Papazahou O, Roussos C. Dynamic hyperinflation and tolerance to interval exercise in patients with advanced COPD. Eur Respir J 2004;24:385-90.

9. Vogiatzis I, Nanas S, Roussos C. Interval training as an alternative modality to continuous exercise in patients with COPD. Eur Respir J 2002;20:12-19.

10. Kortianou EA, Nasis IG, Spetsioti ST, Daskalakis AM, Vogiatzis I. Effectiveness of interval exercise training in

patients with COPD. Cardiopulm Phys Ther J 2010;21:12-19.

11. Mahler D, Gifford AH, Waterman LA, Ward J, Machala S, Baird JC. Mechanism of greater oxygen desaturation during walking compared with cycling in COPD. Chest 2011;140:351-8.

12. Liu WT, Wang CH, Lin HC, Lin SM, Lee KY, Lo YL, et al. Efficacy of a cell phone-based exercise programme for COPD. Eur Respir J 2008;32:651-9.

13. Hernandez MT, Rubio TM, Ruiz FO, Riera HS, Gil RS, Gómez JC. Results of a home-based training program for patients with COPD. Chest 2000;118:106-14.

14. Leung RW, Alison JA, McKeough ZJ, Peters MJ. Ground walk training improves functional exercise capacity more than cycle training in people with chronic obstructive pulmonary disease (COPD): a randomised trial. J Physiother 2010;56:105-12.

15. Ho CF, Maa SH, Shyu YI, Lai YT, Hung TC, Chen HC. Effectiveness of paced walking to music at home for patients with COPD. COPD 2012;9:447-57.

16. Singh SJ, Morgan MD, Hardman AE, Rowe C, Bardsley PA. Comparison of oxygen uptake during a conventional treadmill test and the shuttle walking test in chronic airflow limitation. Eur Respir J 1994;7:2016-20.

17. Pomidori L, Contoli M, Mandolesi G, Cogo A. A simple method for home exercise training in patients with chronic obstructive pulmonary disease: one-year study. J Cardiopulm Rehabil Prev 2012;32:53-7.

18. Party MW. Long term domiciliary oxygen therapy in chronic hypoxic cor pulmonale complicating chronic bronchitis and emphysema. Report of the Medical Research Council Working Party. Lancet 1981;1:681-6.

19. Continuous or nocturnal oxygen therapy in hypoxemic chronic obstructive lung disease: a clinical trial. Nocturnal Oxygen Therapy Trial Group. Ann Intern Med 1980;93:391-8.

20. Vogiatzis I, Athanasopoulos D, Stratakos G, Garagouni C, Koutsoukou A, Boushel R, et al. Exercise-induced skeletal muscle deoxygenation in O-supplemented COPD patients. Scand J Med Sci Sports 2009;19:364-72.

21. Woodcock AA, Gross ER, Geddes DM. Oxygen relieves breathlessness in ‘‘pink puffers’’. Lancet 1981;1:907-9.

22. O’Donnell DE, D’Arsigny C, Webb KA. Effects of hyperoxia on ventilatory limitation during exercise in advanced chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2001;163:892-8.

23. Puhan MA, Schunemann HJ, Frey M, Bachmann LM. Value of supplemental interventions to enhance the effectiveness of physical exercise during respiratory rehabilitation in COPD patients. A systematic review. Respir Res 2004;5(1):25.

24. Guell Rous R. Long-term oxygen therapy: are we prescribing appropriately? Int J Chron Obstruct Pulmon Dis 2008;3:231-7.

25. Emtner M, Porszasz J, Burns M, Somfay A, Casaburi R. Benefits of supplemental oxygen in exercise training in nonhypoxemic chronic obstructive pulmonary disease patients. Am J Respir Crit Care Med 2003;168:1034-42.

26. Gosselink R, Troosters T, Decramer M. Peripheral muscle weakness contributes to exercise limitation in COPD. Am J Respir Crit Care Med 1996;153:976-80.

27. Hamilton AL, Killian KJ, Summers E, Jones NL. Muscle strength, symptom intensity, and exercise capacity in patients with cardiorespiratory disorders. Am J Respir Crit Care Med 1995;152:2021-31.

28. Troosters T, Casaburi R, Gosselink R, Decramer M. Pulmonary rehabilitation in chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2005;172:19-38.

29. Spruit MA, Gosselink R, Troosters T, De Paepe K, Decramer M. Resistance versus endurance training in patients with COPD and peripheral muscle weakness. Eur Respir J 2002;19:1072-8.

30. Ortega F, Toral J, Cejudo P, Villagomez R, Sánchez H, Castillo J, et al. Comparison of effects of strength and endurance training in patients with chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2002;

166:669-74.

31. Simpson K, Killian K, McCartney N, Stubbing DG, Jones NL. Randomised controlled trial of weightlifting exercise in patients with chronic airflow limitation. Thorax 1992;47:70-5.

32. O'Shea SD, Taylor NF, Paratz JD. Progressive resistance exercise improves muscle strength and may improve elements of performance of daily activities for people with COPD: a systematic review. Chest 2009;136:1269-83.

33. Nici L, ZuWallack R, Wouters E, Donner CF. On pulmonary rehabilitation and the flight of the bumblebee: the ATS/ERS Statement on Pulmonary Rehabilitation. Eur Respir J 2006;28:461-2.

34. Walker M, Sussman D, Tamburello M, VanLunen B, Dowling E, Jamali BE. Relationship between maximum strength and relative endurance for the empty can exercise. J Sport Rehabil 2003;12:31-8.

35. Kraemer WJ, Ratamess NA. Fundamentals of resistance training: progression and exercise prescription. Med Sci Sports Exerc 2004;36:674-88.

36. Kraemer WJ, Adams K, Cafarelli E, Dudley GA, Dooly C, Feigenbaum MS, et al. American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. Med Sci Sports Exerc 2002;34:364-80.