High-intensity interval training among healthy older adults. A systematic review

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Summary

Introduction: Due to demographic changes in fertility and mortality, it is predicted that in 2050 the proportion of the world population aged 60 and over will increase from 11% to 22%.
Objective: To analyze the effects of high-intensity interval training in healthy older adults.
Material and method: A bibliographic search was carried out in the following Pubmed, Scielo and ScienceDirect databases, using the Boolean terms High-intensity interval excercise OR High-intensity interval training OR high intensity interval activity AND aged OR older adult OR elderly. The PICoR strategy was used to define eligibility criteria (P) Healthy Older Adults, (I) Use High Intensity Interval Training (HIIT), (C) be subjected to evaluation using the PEDRO scale and obtain a score equal to or greater than 6 points, (O) effect of high-intensity interval training in Adults Healthy elderly (S) studies with control groups or other interventions, published between the years 2016 to 2021.
Results: 1.516 articles were identified, but only those that met the inclusion criteria (7 studies) were included. Significant improvements in sleep quality, fatigue, and body composition were obtained by combining HIIT training with nutritional support. Other improvements were obtained in strength, anabolic hormones, blood lipids, VO2max, exercise tolerance, and systolic BP using only HIIT training.
Conclusion: The adapted HIIT training is applicable to healthy older adults and causes significant improvements in this age group.

Key words:
High-intensity interval training. Healthy older adult. Sports training.

Entrenamiento intervalado de alta-intensidad en el adulto mayor sano. Una revisión sistemática

Resumen

Introducción: Debido a los cambios demográficos de fecundidad y mortalidad se predice que en el año 2050 la proporción de la población mundial de 60 años y más, aumentará del 11% al 22%.
Objetivo: Analizar los efectos del entrenamiento intervalado de alta-intensidad en el adulto mayor sano.
Material y método: Se realizó una búsqueda bibliográfica en las siguientes bases de datos Pubmed, Scielo y ScienceDirect, con la utilización de los términos boleanos High-intensity Interval excercise OR High-intensity interval training OR high intensity interval activity AND aged OR older adult OR elderly. Se utilizó la estrategia PICoR para definir criterios de elegibilidad (P) Adultos mayores sanos, (I) Utilizar Entrenamiento intervalado de alta intensidad (HIIT), (C) ser sometidos a evaluación mediante la escala de PEDRO y obtener en esta un puntaje igual o superior a 6 puntos, (O) efecto del entrenamiento intervalado de alta intensidad en el Adulto Mayor sano (S) estudios con grupos control u otras intervenciones, publicados entre los años 2016 a 2021.
Resultados: Se identificaron 1.516 artículos, pero solo se incluyeron los que cumplieron con los criterios de inclusión (7 estudios). Se obtuvieron mejoras significativas en la calidad de sueño, fatiga y composición corporal combinando un entrenamiento HIIT con apoyo nutricional. Otras mejoras se obtuvieron en fuerza, hormonas anabólicas, lípidos en sangre, Vo2máx, tolerancia al ejercicio y PA sistólica solo utilizando entrenamiento HIIT.
Conclusión: El entrenamiento HIIT adaptado, es aplicable a adultos mayores sanos y provoca mejoras significativas en este grupo etario.

Palabras clave:
Entrenamiento intervalado de alta intensidad. Adulto mayor sano. Entrenamiento deportivo.

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Introduction

The Economic Commission for Latin America and the Caribbean (CEPAL) determines that the ageing population is a consequence of the evolving components of demographic change (fertility and mortality)[1,2]. It predicts that in 2050, the proportion of the world's population aged 60 and over will increase from 11% to 22%. Furthermore, it is said that between 2025 and 2030, the life expectancy in Latin America and the Caribbean will rise to 80.7 years old for women and 74.9 for men[3]. Likewise in Chile, it is expected that by 2025, adults aged over 60 will make up 20% of the population, exceeding the under 15 age bracket from that year onwards[4]. This change implies the challenge of healthy ageing[5], so the National Senior Service (SENAMA)[4], and the Ministry of Health (MINSAL)[6] have implemented a series of programmes to benefit older adults (OA), people who have reached the age of 60 or above. These programmes aim to promote active ageing, encouraging intergenerational encounters, creating favourable environments that provide good quality of life, delay levels of dependency and remain functional and autonomous for as long as possible[7]. It is known that functional impairment is one of the main factors influencing poor quality of life, with lethal effects on their state of health[8].

Ageing is a normal process in the life cycle, characterised by a progressive loss of functional reserve, both molecularly, cellularly and systemically, affecting the physiological capacity of maintaining homoeostasis, which causes changes at a cognitive, physiological, physical, psychological and social level[9,10]. Consequently, the World Health Organisation (WHO)[11] and other authors[12,13] agree that physical exercise during ageing has multiple benefits, including a lower mortality rate in all its causes[11], better functional health[11,14-16], and prevention or delay of cognitive deterioration[14,17].

Considering these benefits and the WHO recommendations for older adults, one striking option is high-intensity interval training (HIIT), which consists of short episodes of high-intensity exercise (>85% of VO_{2max}), alternating with low-intensity active rest or recovery periods (20-40% VO_{2max})[18]. Its main objective is to improve the maximum oxygen consumption (VO_{2max})[19]. This training method has proven to be effective among different populations and in a wide range of pathologies: children[20], teenagers[21] and young adults[22] with cardiometabolic alterations such as obesity[23], diabetes[24], hypertension[25], and metabolic syndrome[26,27]. As Abarzúa *et al*.[28] and Martín *et al*.[29] mention, HIIT induces improvements in muscular and cardiovascular aptitude and body composition among healthy teenagers. It has also proven highly effective among adults, even in heart transplant recipients by improving VO_{2peak}, maximum heart rate, and heart rate reserve[30].

In summary, we can determine that HIIT training, apart from its main objective of improving VO_{2max}, can be highly effective for other variables. However, in relation to using HIIT among older adults, López-Chicharro[19] establishes that considering the actual features of HIIT, it is not possible in physiological terms to apply a real HIIT to older adults, so it must be individualised, adapting to the characteristics of each subject, plus their behaviour, preferences and goals.

According to the above, the aim of this systematic review is to analyse the effects of HIIT training on healthy older adults.

Material and method

This systematic review was performed according to the rules determined in the PRISMA declaration[31].

Search strategy

A bibliographic search was performed in both English and Spanish, for a period between January 2016 and April 2021, using the Pubmed, Scielo, and ScienceDirect databases. The eligibility criteria were determined based on the PICoR strategy:

P (Participants/Population): healthy older adult.

I (Intervention): High-intensity Interval Exercise.

C (Comparison): with control groups or other interventions.

O (Outcomes): effect of high-intensity interval training among healthy older adults.

The search descriptors used were: *High-intensity Interval exercise AND older adult, High-intensity Interval exercise AND elderly, High-intensity Interval exercise AND aged; High-intensity interval training AND older adult, High-intensity interval training AND elderly, High-intensity interval training AND aged; High intensity interval activity AND older adult, High intensity interval activity AND elderly, High intensity interval activity AND aged.*

Selection of articles and inclusion criteria

The inclusion criteria were:

- Sample of healthy older adults.
- Experimental and quasi-experimental papers, controlled - randomised.
- No gender distinction.
- Free articles.

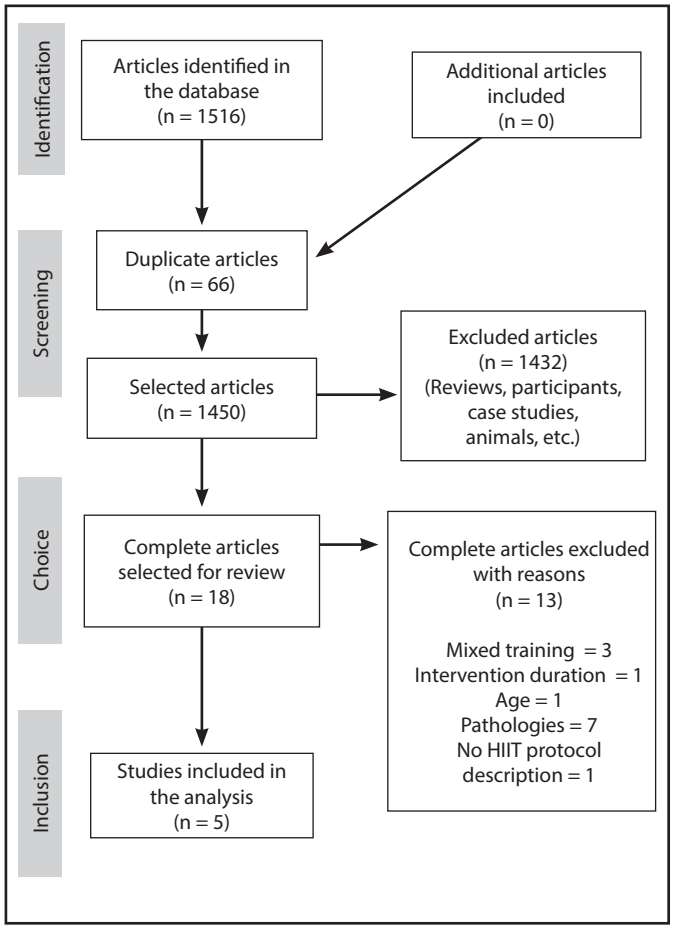
Quality assessment

The methodological quality assessment used the PEDro scale[32]. The PEDro scale is based on the Delphi list developed in the Editorial or Thesis department. The articles selected by title and abstract should meet the conditions indicated in the search strategy (inclusion criteria).

Information collection

The search for articles in the Pubmed, Scielo and ScienceDirect databases produced a total of n=1.516. Sixty-six duplicate articles were removed, and no additional articles were added to the search. From reading the titles and abstracts, 18 articles were selected. Subsequently, based on the complete reading of the articles, 13 articles were excluded for the following reasons: mixed training or combined with other training, uncontrolled pathologies, age under 60, duration of the

Figure 1. Flow chart for study selection.



intervention in years and due to not describing the HIIT intervention, finally selecting 5 articles that meet the inclusion-exclusion criteria (Figure 1) and PEDro scale.

Results

The methodological quality results for each article selected for the systematic review are presented in Table 1, which present methodological quality according to the PEDro scale between 6 and 9 points.

It is considered that studies scoring 9-10 on the PEDro scale have excellent methodological quality. Studies with a score between 6-8 have good methodological quality, between 4-5 regular quality and below 4 points poor methodological quality[33], so in general the selected articles present good methodological quality.

Table 2 presents the variables studied in the included articles. Based on the information compiled, we obtained a total studied population of 245 older adults: men (n=115) and women (n=130), aged 60 or over, who were assigned at random to groups of HIIT vs MIIC[34], HIIT v/s aerobic training[35], HIIT+CIT v/s HIIT+PLA[36], HIIT v/s GC[37], and HIIRT v/s TRT[38].

The total volume of the interventions made in the selected articles is between 2 and 12 weeks of application, with a frequency of 2 to 3 times a week, the duration of each training session varies between 16.5 min and 60 min including the warmup and cool-down (see Table 3).

The drop-out percentage among participants in the studies by Herrod and Bruseghini was 0%[35,37], while in Moro's study, although 34% dropped out, only 11% represented the HIIT group[38], as in the study by Buckinxet *et al.*[36] where the drop-out rate was lower for HIIT than in other types of training.

In relation to the outcomes (sleep quality and fatigue)[34], there were no significant differences between the HIIT and MIICT groups. However, the HIIT group did obtain significant PRE-POST differences regarding improved sleep quality and, in turn, a significant drop in their fatigue scores.

Regarding body composition and the effect of HIIT, HIIT significantly improved the body composition in the study by Buckinx *et al.*[36] which assesses the influence of ingesting proteins on the combined effect of HIIT+CIT, significantly decreasing the total fat mass and significantly increasing the lean mass, while in articles by Moro *et al.*[38] and Herrod *et al.*[37], there were slight but not significant changes. The study by Buckinx *et al.*[36] also demonstrated that HIIT combined with ingesting Citrulline would be more beneficial in obese older adults who eat less than 1 g/kg/day of protein a day as there are greater improvements in the body composition. Regarding muscle strength that is assessed in two studies, both saw a significant improvement[36,38].

In the functional abilities, HIIT scored significant improvements for all parameters (Timed up and go test, support test in chair, one-leg balance test, 6-min walking test). However, differences between groups were not significant[36]. Regarding the maximum oxygen consumption, this rose significantly after 6 weeks of HIIT, but not 4 or 2 weeks from the intervention[37]; for tolerance to the HIIT exercise, there was a significant

Table 1. PEDro scale to assess the methodological quality of the selected studies (n = 5).

Authors-year	1	2	3	4	5	6	7	8	9	10	11	Total score
Jiménez *et al.*[34]	1	1	1	1	0	0	1	1	1	1	1	9
Bruseghini *et al.*[35]	1	1	0	0	0	0	0	1	1	1	1	6
Buckinx *et al.*[36]	1	1	1	0	0	0	0	0	1	1	1	6
Herrod *et al.*[37]	1	1	0	1	0	1	1	1	1	1	1	9
Moro *et al.*[38]	1	1	1	1	0	0	0	0	1	1	1	7

Table 2. Variables studied from the included articles (n = 5).

Authors-year	Participants	Intervention	Comparison	Outcomes	Result
Jiménez *et al.*[34]	n = 73 (H = 17, M = 56) (HIIT = 26, MIICT = 24, GC = 23)	12 weeks (2/week) 45' x session, HIIT 4X4' 90-95% FCM TRX MIICT 70% FCM TRX	HIIT V/S MIICT	Sleep quality Fatigue	↑ ↓
Bruseghini *et al.*[35]	n = 24 (H = 24) (HIIT =12, Aerobic = 12)	8 weeks (3/week) HIIT Bike 7x2 85-95% VO_{2max}.	HIIT V/S Aerobic	Physical activity Energy expenditure	↑ =
Buckinx *et al.*[36]	n = 73 (H = 33, M = 40)	12 weeks (3/week) HIIT Elliptic trainer 10 x 30" (80-85%) x 90" (65%)FC_{max}.	HIIT+CIT V/S HIIT+PLA	Body composition Muscle strength Functional abilities	↑ ↑ ↑
Herrod *et al.*[37]	n = 40 (H = 21, M = 19) (HIIT = 30, GC = 10)	2-4-6 week (3/week) HIIT static bike 5 x 60" (90% -110% $POT_{max.}$) x 90" (Active)	HIIT V/S CG	Anaerobic threshold VO_{2max} Tolerance to exercise Systolic arterial pressure Diastolic arterial pressure Body composition	= ↑ ↑ ↓ = =
Moro *et al.*[38]	n = 35 (H = 20, M = 15) (HIIT = 18, TRT = 17)	16 weeks (2/week) HIIT of strength 6RM (80%) x 20" + rep to fail (80%) x 20" + 2-3 rep (80%) x 2'30"	HIIRT V/S TRT	Body composition Strength Anabolic hormones Lipids in the blood	= ↑ ↑ ↑

HIIT: High-intensity interval training; MIICT: Moderate-intensity interval training; CIT: Citrulline; PLA: Placebo; CG: Control group; HIIRT: High-intensity interval resistance training; TRT: Traditional Resistance Training.
*Statistically significant difference in HIIT/outcomes.

Table 3. Intervention characteristics.

Articles	Participants	Method/ intensity	Frequency times a week	Duration	Recovery	Total time (min)	Intervention duration (week)
Jiménez *et al.*[34]	n = 26	TRX 90-95% maximum pulse rate	2	4 x 4 min.	3 min.	48	12
Bruseghini *et al.*[35]	n = 12	Cycling 85%-95% VO_{2max}.	3	7 x 2min	2 min. 40% $VO_{2max.}$	45 - 60	8
Buckinx *et al.*[36]	n = 73 (H = 33, M = 40)	Elliptic trainer 80%-85% HR_{max}.	3	10 x 30 seg.	90 seg. 65% $FC_{max.}$	30	12
Herrod *et al.*[37]	n = 30	Cycling 90%-110% POT_{max}	3	5 x 1min.	90 s	16.5	2 4 6
Moro *et al.*[38]	n=18	6 RM 80% 1 RM	2	It is measured in repetitions x RM	20 s	45	16

interaction demonstrated in the 2, 4 and 6 weeks of training[37]; for the systolic arterial pressure (SAP) at rest, HIIT demonstrates a significant drop after 4 and 6 weeks of training, but not after 2 weeks and there were no significant differences in diastolic arterial pressure after 2, 4 or 6 weeks of HIIT training[37]. Finally, and in relation to anabolic hormones and lipids in the blood, although cortisol levels were higher in both training groups (TRT and HIIRT), this was only statistically significant in the HIIRT group; insulin only dropped significantly for the HIIRT group; the baseline level of growth hormone (GH) dropped significantly in TRT and not in HIIRT; both groups saw an improvement in their lipidic profile, but only HIIRT obtained statistically significant differences ($p < 0.05$)[38].

Another finding is that HIIT does not negatively affect the lifestyle of active older adults, as it does not reduce daily energy expenditure or increase sedentary time[34].

Discussion

The aim of this review was to assess the effects of a HIIT programme as a means of healthy training in healthy older adults (>60 years old). The studies included have demonstrated that using a well-applied and controlled HIIT among older adults effectively shows improvements in different indicators such as: sleep quality and fatigue[34],, energy expenditure[35]; functional capacity and body composition[36]; physical strength[37]; muscle strength[36,38]; tolerance to exercise[37]; anabolic hormones and lipids in the blood[38]; systolic arterial pressure and VO_{2max}[37].

When referring to sleep quality, in this aspect Štefan *et al.*[39] demonstrates that older people who report a short sleep duration are less likely to meet the physical activity recommendations for their age group. However, people who report a prolonged sleep duration and

good sleep quality are more likely to meet these same recommendations. There are also many therapeutic interventions for sleep treatment, including pharmaceutical treatments[40], however, due to their side effects, non-pharmacological interventions are recommended[41] such as physical exercise[42].

Regarding VO_{2max}, frequently used as a cardiorespiratory fitness indicator and considered fundamental to promote health[43], analysis of the results shows us that 6 weeks or more of HIIT are required to observe a significant improvement, and the same can be said for the resting SAP which requires a minimum of 4-6 weeks of intervention, in line with the study by Wen *et al.*[44] and Batacan *et al.*[45] which recommends long interval HIIT (≥2min), with high volume (≥15min) and moderate to long term (≥4-12 weeks) to maximise the effects on VO_{2max}.

It could also be seen that a combination of HIIT with nutritional support can increase the beneficial effects in the body composition of Older Adults with obesity[46].

Although the HIIT training obtained all these improvements, it is important to mention that, among the articles studied, no two protocols are alike, either in quantity of intervals, training method (TRX, cycling, elliptic trainer, static bike, RM) or total duration of the intervention, so it is difficult to determine the ideal protocol to generate significant changes in older adults. However, something important that they do have in common is the low percentage of drop-outs or injuries related to the training, even 0%[35,37], which supports the motion that HIIT is a good training strategy that stimulates adaptations in healthy older adults[47], and in other articles[34,36,38] where subjects do drop out, this refers to no more than 2 to 4 participants, and their reasons for this are not related to the HIIT training.

To adapt the participation of the Older Adults in HIIT, the scientific evidence even suggests including an adaptation period of 4 weeks[38], prior to the HIIT which involves strength exercises, and also carrying out HIIT with low impact exercises, on the static bike or elliptic trainer when working with obese and/or sedentary adults, to thereby reduce the risk of injuries and the percentage of drop-outs.

The results obtained in this review paper can be considered novel and positive, given the beneficial effects of a HIIT intervention on a healthy elderly adult, where an adapted programme can bring about significant improvements, with a minimum of 4 weeks of interventions, in maximum heart rate, systolic arterial pressure at rest, quality of sleep and tolerance to fatigue, as well as reducing the baseline insulin levels and reduction of baseline cholesterol considered as a good non-pharmacological way of improving their lifestyle, with no compensatory effects on older adults.

Conclusion

In conclusion, the 5 articles under review provide evidence that adapted HIIT can lead to significant improvements in healthy older adults, involving a minimum of 4 weeks of interventions, with improvement in maximum heart rate, systolic arterial pressure at rest, quality of sleep and tolerance to fatigue, as well as reducing the baseline insulin levels and reduction of baseline cholesterol considered as a good non-pharmacological way of improving their lifestyle, with no compensatory effects on older adults.

Conflicts of interest

The authors declare that there is no conflict of interest.

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