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Summary / Sumario

Exercise/physical activity programmes to combat a sedentary lifestyle, chronicity and poor ageing

Contra el sedentarismo, la cronicidad y el mal envejecimiento, programas de actividad física/ejercicio

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Nowadays, no one questions the value of physical activity and, essentially, physical exercise programmes, as a health tool and important factor in social and healthcare policies. Regular and well-planned exercise is prescribed as non-pharmacological treatment for most diseases prevalent in developed societies, regardless of the need for rehabilitation or specific treatment for a particular system that is specifically damaged[1,2]. It is also prescribed as a preventive factor for almost all diseases[1,2], regardless of a patient's gender or age. Scientific evidence strongly demonstrates that, beyond its health value, and much more than medicine, regular exercise is a source of *life* in our societies that are ageing, sedentary and often extremely socially isolated.

Much more than medicine, movement is life

Today we know that ageing is a gradual, multifactorial process of irreversible and stochastic deterioration, affecting the metabolic, cardiorespiratory and endocrine functions, the immune responses, the inflammatory processes, the performance of the osteo-ligamentous-tendinous-muscular system and, of course, cognitive functions, the regulation of the nervous system and, in general, motor control[3,4]. The magnitude and persistence of these changes are such that they are accompanied by alterations in the physical condition, motor and mental skills and, in general, the functionality and relationship capacity of older adults.

We are also aware that a sedentary life multiplies any adverse effects such as persistent inflammation and sympathetic nervous system arousal, together with an equally persistent vagal inhibition and, in general, autonomic dysfunction. Among other consequences: pathology chronicity, sarcopenia, emotional disorders, depression, mental illnesses, and, at the end of this continuum, decrease in disability-free life expectancy, multiple pathologies, fragility and dependency[5].

A sedentary lifestyle entails systemic disuse or detraining, resulting in the alteration of the neural responses and effort intolerance in these older adults or with limiting pathologies. This make motricity more difficult and movement is perceived as more demanding, more fatiguing. Acting as a feedback loop, psychomotor deterioration induces even greater sedentarism and ends in functional incapacity, autonomic dysfunction and loss of allostasis/resilience, aggravating the already deteriorating effects of the ageing process.

Furthermore, the shortcomings in the motor sphere of a person who feels clumsy, with little or no ability, limit the development of psychomotor and psychosocial skills, hinder efficiency and often involve frustration, with the subsequent lack of motivation to exercise[6]. Yet again, this is particularly important in the case of older adults and, above all, in those with some type of cognitive or motor skill impairment. These people often age alone and with little resources, requiring powerful interventions in the area of functional improvement and their physical re-education, beyond the improvement or reduction in the symptoms of their pathologies.

It should be noted that physically competent individuals understand and face up to the challenges of motricity, moving with economy and confidence, and can safely and empathetically establish relationships with others and with their environment throughout their life[6]. It should also be remembered that, at the opposite end, adults that feel insecure and are afraid to relate to their environment, hardly go out and frequently end up in unwanted loneliness that is related to the risk of poor health, comorbidity, and, once again, fragility and dependency.

Sustained over time, unwanted loneliness is the absence of incentives and an accelerated journey towards physical inactivity and pathology, giving another turn of the screw in the poor sedentary ageing loop. If we add to this factors such as a greater risk of falls and/or an increase in mental disorders in these ageing and lonely groups, then the cocktail is served. Let's do some figures.

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Exercise is good at all ages

In general, the Consejo Superior de Deportes (CSD - Sports Council of Spain) calculates a saving of between 3 to 15 euro in healthcare expenditure for each euro invested in physical activity/exercise programmes, emphasising that Sport and Health must go hand in hand, as a strategic approach to social and healthcare policies. The return on investment (ROI) in *exercise*, is high.

Today there is no doubt of the benefits of increasing physical activity/exercise together with the necessary reduction in sedentary behaviours, given that sufficient amount and intensity of movement demands the complete participation of all our systems, helping to improve/maintain our adaptive responses[5,7]. When the proposal is demanding and holistic, exercise stands as a powerful neurophysiological tool, capable of ensuring the communication of all our cell organelles and systems in a unified and coordinated way[7]. And when this same movement occurs within the framework of leisure and active free time, despite its lower physiological impact - resulting from its lower intensity - there are also alternative pathways to lead to the same improvements[5]. And it continues to be a powerful tool.

In the words of Bennett, Reeves[5], the stress pathways are acutely activated and support the physical exertion demanded to move the body through the physical activity, particularly with regard to concerted exercise. This physiological challenge makes it possible to activate the sympathetic branch of the nervous system and the hypothalamic-pituitary axis, and to stop it at the end of the effort, giving rise to a very healthy post-effort "rebound". This greater specific inflammation is accompanied by a reduction of inflammation at rest, as well as the release of myokines (muscular cytokines) to attract immune cells to repair the tissue damage, also promoting microbiota diversity and gut health[5].

The binomial "more physical activity/exercise - less sedentarism" is key to our individual and collective health, with greater impact as we grow older.

As reported by Lazarus, Lord[3],there are systems that are age-dependent but are not malleable by exercise (a), systems that are age dependent and are also malleable by exercise (b), systems that are not age dependent but are malleable by exercise (c), and finally, systems that are unaffected by age or exercise (d). The understanding of these balances makes it possible to appreciate that, above the impact of ageing, physical activity/exercise leads to what is known as the *healthy ageing phenotype* (active, successful); while, at the other end, inactivity/sedentarism condemns individuals to thepathological ageing phenotype (inactive). The success of the former lies in maintaining the *"intrinsic capacity"* intact, in other words, the possibility to continue doing those simple things that make a human being feel mentally and physically *capable*[3]. In the words of these same authors: walk, think, perceive (see, hear...) and remember.

Far from settling for a minimum number of minutes of physical activity, in its recent guidelines for physical exercise the WHO[8] concludes that older adults must be as physically active as their functional ability allows, adjusting their level of effort to their level of fitness and to their functional abilities so as not to fall below their motor requirements. This also applies to adults with chronic conditions. The WHO also indicates that those adults with greater difficulties may wish to consult a physical activity specialist or health-care professional for advice on the types and amounts of activity appropriate to their individual needs, abilities, functional limitations/complications, medications and overall treatment plan[8].

At this stage, the first thing to do is to *start, to get going*. The second, but no less important, point is to gain the older adult's *loyalty* to exercise by finding something that is sufficiently attractive for those who have not taken part in exercise programs for a long time (if indeed they ever have) so that they are sufficiently motivated to allow them to overcome their general disinclination to exercise.

Conquer their fears, personalise the proposal, address the heterogeneity of older adults and respect their pace.

It will also be extremely important to support them in the process and not leave them alone once the first improvements are made, because age is accompanied by a high level of *detrainability*, understanding this to be the loss of physical fitness associated with detraining[4]. Although qualities such as agility or the executive function itself appear to hold up well for a certain amount of time, despite the detraining (negative or regressive effect associated with stopping training), the reduction or even the disappearance of gains is particularly accentuated in the cardiovascular and strength capacities, entailing a loss of physical fitness and the reappearance of fatigue levels[4], with a risk of returning to the centre of the loop.

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Original article

Performance analysis of women over 55 years on abdominal tests: impact of anthropometry and flexibility

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Summary

The objective of the present study was to evaluate the effect of anthropometric variables and flexibility on the performance of women aged 55+ years on abdominal test protocols. The sample was composed by 20 physically active volunteers, aged 55 years (median 61), who were participants in gymnastic activities program. Each volunteer performed two abdominal tests: partial trunk flexion with a 7.6 cm sliding of the hands (P1) and partial flexion of the trunk with the hands on the thighs (P2), both executed with the feet resting on the ground. For analysis, the number of correct executions (final position) was considered in each test, as recommended by the authors. Measurements of body mass, flexibility, height, waist and hip perimeters, subjective perception of exertion, and calculations of body mass index and waist-hip ratio were performed. The perception of abdominal effort, and discomfort or pain in the cervical and lumbar region were also evaluated. The results showed that there were no statistically significant associations between the analyzed indicators (Age: P1: rs = -0.024, p = 0.916; P2: rs = -0.194, p = 0.407; BMI: P1: rs =-0.064, p = 0.792; P2: rs = -0.235, p= 0.327; Waist Circumference: P1: rs = -0.143, p = 0.563; P2: rs = 0.027, p = 0.908; Flexibility: r s= -0.327, p = 0.169; P2: rs = 0.0009, p = 0.991; Hip waist ratio: P1: rs = -0.209, p = 0.371; P2: rs = 0.217, p = 0.353) and the performance on the tests. In addition, 35% of the participants made valid attempts on P1 while 45% produced at least one valid attempt on P2. It was concluded that both abdominal tests were adequate for the studied sample and they can be applied to adult and elderly women to assess their abdominal musculature.

Key words:
Abdominal muscles. Exercise test. Elderly. Anthropometry.

Análisis del desempeño de mujeres mayores de 55 años en test abdominales: impacto de la antropometría y flexibilidad

Resumen

El objetivo del presente estudio fue evaluar el efecto de las variables las antropométricas y la flexibilidad sobre el desempeño de mujeres mayores de 55 años en protocolos de testes abdominales. La muestra, seleccionada por criterio de accesibilidad, estuvo formada por 20 voluntarias físicamente activas, mayores de 55 años (mediana 61), que participaban en actividades gimnásticas para personas mayores. Cada voluntaria realizó dos pruebas abdominales: flexión parcial del tronco con deslizamiento de las manos de 7,6 cm (P1) y flexión parcial del tronco con las manos en los muslos (P2), ambas ejecutadas con los pies apoyados en el suelo. Para el análisis, se consideró el número de ejecuciones correctas (posición final) en cada prueba, según lo recomendado por los autores. Se realizaron mediciones de masa corporal, flexibilidad, altura, perímetro de cintura y cadera, percepción subjetiva del esfuerzo y cálculos del índice de masa corporal y la relación cintura-cadera. También se evaluó la percepción de esfuerzo abdominal y de malestar o dolor en la región cervical y lumbar. Los resultados mostraron que no hubo asociaciones estadísticamente significativas entre las variables analizadas (Edad: P1: rs = -0,024, p = 0,916; P2: rs = -0,194, p = 0,407; IMC: P1: rs =-0,064, p = 0,792; P2: rs = -0,235, p = 0,327; Perímetro de cintura: P1: rs = -0,143, p = 0,563; P2: rs = 0,027, p = 0,908; Flexibilidad: rs = -0,327, p = 0,169; P2: rs = 0,0009, p = 0,991; Relación cintura/cadera: P1: rs = -0,209, p = 0,371; P2: rs = 0,217, p = 0,353) y el desempeño en las pruebas, y el 35% de las participantes hicieron intentos válidos en P1 mientras que el 45% produjo al menos un intento válido en P2. Se concluyó que ambas pruebas abdominales fueron adecuadas para la muestra estudiada y se pueden aplicar a mujeres adultas y mayores para evaluar su musculatura abdominal.

Palabras clave:
Músculos abdominales. Prueba de esfuerzo. Anciano. Antropometría.

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Introduction

Studies on musculoskeletal fitness in people 55+ years old have shown that its components (especially strength, flexibility, and muscular endurance) are positively associated with health status, i.e., they have a predictive relationship with mortality[1-3]. In order to evaluate these aspects, fitness tests are generally used to evaluate functional capacity through the assessment of balance, upper and lower limb strength and resistance, displacement velocity, distance traveled, and flexibility[4]. However, the evaluation of abdominal resistance is not usually studied.

The preservation of abdominal strength during the aging process is fundamental for the support and containment of the abdominal contents, for the maintenance of the normal posture of the pelvis, and for the production and control of the movement of the trunk during flexion and rotation of the trunk[5]. Moreover, abdominal strength is indirectly responsible for the curvature of the lumbar spine and essential for maintaining body posture[6,7]. Furthermore, weakness of the abdominal muscles is associated with disorders such as ptosis or anterior projection of the abdominal region; difficulty raising the head while supine; impairments in breathing and in performing certain movements such as coughing, vomiting, and sneezing. Also, accentuation of lumbar lordosis, the latter being due to the disproportionate strengthening of the psoas major muscle in relation to the abdominal muscles, which causes low back pain[2].

Anthropometrics variables and flexibility undergoes significant physiological changes during the aging process[8,9]. We hypothesized that this change can affect the performance of people 55+ years old on abdominal tests. However, the relationship between anthropometrics variables, flexibility, and performance is not adequately clarified in the literature.

It is also unclear what factors can interfere with the performance of abdominal exercises, being a problem to be answered. All modifications resulting from the aging process should be considered in the evaluation of the performance of the abdominal muscles of women 55+ years old. Mainly because they can be a source of errors, especially if the performance of this test is evaluated against the protocols for abdominal tests proposed for young people and adults.

In view of the above, the present study aimed to evaluate the effect of anthropometric variables and flexibility on the performance of women aged 55+ years on two abdominal test protocols. Our hypothesis is that anthropometric variables and flexibility will be directly associated with the performance of women aged 55+ years in the proposed abdominal tests.

Materials and method

Participants

The sample of the present study was composed of physically active women. The following inclusion criteria were adopted: participants were required to be 55+ years old; be women; be clinically fit for regular physical exercise; be physically active, practicing physical exercises for at least 1 year with a frequency of 3 times a week; not have any acute or chronic illness that could be affected by the exercise; have experience in performing abdominal exercises; and consenting freely and voluntarily to perform all study procedures. The exclusion criteria were: presenting bone or joint limitation during the intervention, which prevented the performance of the abdominal exercises; and having used pharmacological drugs, which could affect the result of anthropometrics and functional assessments.

Those who agreed to participate signed an informed consent form. All procedures were approved by the Ethics Committee on Human Research of the Federal University of Viçosa, according to Resolution 466/2012 of the National Ethics Committee (CONEP), the National Health Council, in accordance with the ethical principles expressed in the Declaration of Helsinki.

The present study is observational and prospective research, with crossover design, being carried out in its entirety, in the Morphophysiology Laboratory of the Physical Education course of the Federal University of Viçosa (UFV).

Interventions

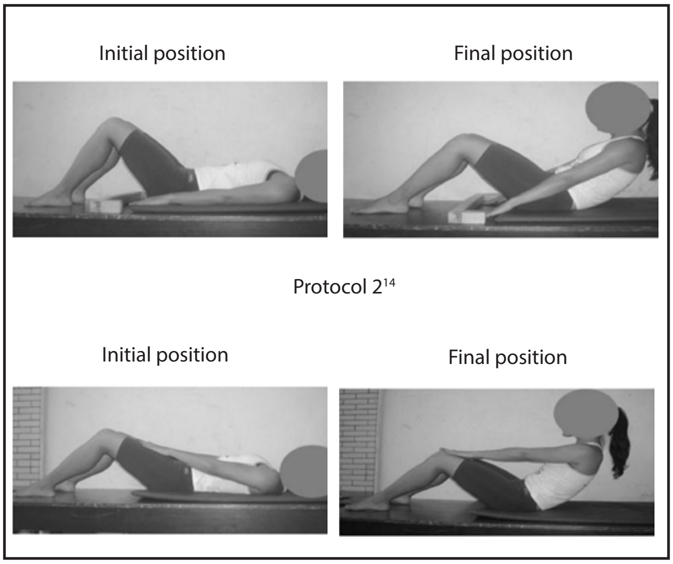
The data collection was performed on alternate days by two fully trained kinesiologists. The participants were individually evaluated by the same evaluator in a private setting and the order of execution of the tests was determined at random. A warm-up was not allowed before each test was conducted.

Two abdominal tests were used to evaluate abdominal muscle strength, both of which were chosen based on an earlier study[10]. This choice was made because the participants reported a low rate of discomfort or pain in the cervical and/or lumbar spine. The characteristics of the two protocols are described in Table 1 and Figure 1.

Table 1. Abdominal test protocols with respective duration, feet position, form of execution and number of repetitions.

Tests	Duration (min)	Feet Position	Execution	Number of repetitions
Protocol 1 (P1) - partial flexion of the trunk and sliding hands 7.6 cm (13)	1	On the ground	From the extremity of the middle fingers, set 7.6 cm on the ground; in the initial position, flex the trunk and slide hands on the ground trying to reach the 7.6 cm mark.	Higher number of repetitions
Protocol 2 (P2) - partial flexion of the trunk and hands on thighs (14)	6	On the ground	With knees bent between 120-140°; set a mark on the top edge of the patella. From the initial position, flex the trunk and slide hands on thighs until they touch the mark held on the knees.	Cadenced test; 20 repetitions/min; maximum 120 repetitions

Figure 1. Illustrative pictures of initial and final positions of the five abdominal test protocols used.



Outcomes

On the first day, before the abdominal tests execution, anthropometric measures were taken, in each volunteer, (body mass [kg] and height [cm]) to calculate the BMI and also the waist-to-hip ratio[11]. Flexibility was also assessed through the sit-and-reach test (cm)[12].

For analysis of performance in the abdominal protocols, the number of correct executions (reaching the correct final position) was considered in each test, as recommended by the developers of these tests[13,14]. All volunteers complied with the timeframes of the test protocols, regardless of whether they performed them correctly or not. In the paced test (P2), a mechanical metronome was used, with a frequency capacity of 40 to 208 beats per minute. The instrument was presented to the participants on the day before the test, to familiarize them with the rhythm to be followed.

At the end of each test, the 20 point Borg scale[15] was used to indicate the subjective perception of effort (RPE) and a scale of 0 to 4 points was used to verify the perception of discomfort or pain in the cervical and lumbar spine, effort of the abdominal muscles (0 = no discomfort/ effort, 1 = very little, 2 = moderate, 3 = intense, 4 = very intense).

Sample size calculation

Considering Wilcoxon test, a priori calculation, an effect size f of 0.8 for abdominal performance[10], an α of 5% and a power of 95%. The sample size calculation performed by the G-Power® program at the University of Dusseldorf, indicated that a total sample size of 20 individuals. Thus, the total sample size was of 20 physically active women 55+ years old.

Statistical methods

The data were described as median, minimum and maximum values. The normality was verified by the Shapiro Wilk test. Comparisons between the abdominal tests were made by the Wilcoxon test and the relations among the variables were evaluated by the Spearman correlation. Interpretation of the Spearman correlation was assessed according to the following criteria: 0–0.30 negligible, 0.30–0.50 weak, 0.50–0.70 moderate, 0.70–0.90 strong, and 0.90–1.00 very strong[16]. The effect size was calculated using "r" test for Wilcoxon test. Values were classified as insignificant (<0.20), small (0.20-0.49), medium (0.50-0.79) and large (> 0.79)[17]. For all analyses, the significance level was set at $p < 0.05$.

Results

The data of the anthropometric characterization of the participants is shown in Table 2 and the results of the correct execution, the RPE, the perception of discomfort or pain in the cervical and lumbar spine and abdominal muscle effort, and the comparison of the medians of the variables studied in the two tests can be seen in Table 3.

Table 2. Mean, minimum and maximum values of the variables of anthropometric characterization of the sample.

	Median	Minimum	Maximum
Age (years)	61	55	73
Body mass (kg)	60.8	49.8	80
Height (cm)	153.5	143	160
Body Mass Index (Kg/m²)	26.32	22.56	35.32
Waist circumference (cm)	84.65	71	108
Waist-hip ratio	0.862	0.742	1.023
Flexibility (cm)	31	16	44.3

Table 3. Results (median, minimum and maximum value) of correct performances, rating of perceived exertion (RPE), perception of abdominal muscle effort, perception of discomfort or pain in the cervical and lumbar spine and comparison of medians of the P1 test[13] and P2[14].

	P1				P2			
	Med	Min	Max	Med	Min	Max	p*	ES
Correct Executions	0	0	48	0	0	23	0,497	0
RPE	12	9	15	13	7	17	0,083	0,07
Perceived abdominal effort	3	1	4	1	0	3	0,320	0,5
Pain in the cervical region	1	1	4	0	0	2	0,147	0,25
Pain in the lower back	1	1	3	0	0	1	0,375	0,33

*p-value obtained through the Wilcoxon test; ES: effect size; RPE: Rating of perceived exertion; Med: Median; Min: Minimum; Max: Maximum.

Table 4. Performance ratio in the two abdominal tests with age, body mass index, waist circumference, flexibility and waist/hip ratio.

	P1		P2	
	rs	P	rs	P
Age (years)	-0.024	0.916	-0.194	0.407
BMI (Kg/m²)	-0.064	0.792	-0.235	0.327
Waist Circumference (cm)	-0.143	0.563	0.027	0.908
Flexibility (cm)	-0.327	0.169	0.0009	0.991
Hip waist ratio	-0.209	0.371	0.217	0.353

BMI: Body Mass Index; rs: Spearman correlation.

Comparing the BMI values obtained with the values recommended by WHO[18], the participants were in general overweight and also classified as "high risk" for cardiovascular diseases by waist circumference (WC) and waist-to-hip ratio[18]. The flexibility result, when compared to the reference values[18], ranked the group as "good."

The results did not identify any statistically significant differences for all variables measured. Although a greater number of correct executions were obtained for P1, during the tests it was observed that the number of women who achieved at least one correct execution was higher for P2. The associations between test performance and anthropometric parameters are shown in Table 4, and there were no significant correlations.

Discussion

The present study aimed to evaluate the effect of anthropometric variables and flexibility on the performance of women aged 55+ years on two abdominal test protocols. The main results founded were: 1) there no significant differences in performance between the two protocols; 2) the two tests did not present significant differences for RPE, perception of abdominal effort, or perception of pain in the cervical and lumbar region; 3) there no associations between tests performance and anthropometric indicators or flexibility.

The difference in performance between the two tests was not significant (p = 0,497), noting that the median values for both were zero, indicating the difficulty the women had in their performance. This high degree of difficulty can also be verified by the median value of RPE (Table 3), indicating that both constitute exercises that require moderate to intense muscular effort, depending on individual physical fitness. However, they are abdominal tests that do not seem to impose excessive stress on the cervical and lumbar spine, as reported by the participants.

The individual performances for P1, when classified according to MacFarlane[19], showed three volunteers with weak performance, one below average and 16 unrated (below "weak"). For P2, the norm proposed by Jetté, Quenneville and Sidney[20] shows that three evaluated could not be classified because there were no parameters for the age group in question, eight had poor performance, five were below average, two average, and one above average. Therefore, if we consider individual performance only on the basis of the number of correct runs by strictly observing the test protocols, it can be inferred that, although the elderly women regularly participated in physical activities, their usual exercise program may not develop a compatible abdominal strength level with that required to achieve an expected average result for sex and age group. The physical fitness level of the patients evaluated the stage of aging they are in and the physiological changes resulting from this process, the characteristics of the population used to construct the reference values and tests, and the different physical requirements for performing these abdominal tests can also be related to performance.

Another important aspect is that each test requires distinct physical abilities that also manifest in different ways in the various phases of life. P1 is characterized by being a test where the speed of execution is an important prerequisite, because one must execute the greatest possible number of repetitions in a minute, which quickly leads to muscular fatigue. Logic indicates that 1 minute tests reflect much more than just muscular strength and instead also require muscular endurance[21]. P1 presented a higher number of correct replicates, but only by four of the women. Another important aspect with respect to P1 is the requirement for increased spine flexion to slip the hands on the ground and reach the 7.6 cm mark, which could result in pain in the cervical and lumbar region. This requirement, coupled with the speed required to perform the test, imposed a significant stress on the spine, possibly making the test uncomfortable for some people.

P2 was a cadenced test, lasting six minutes, and more women were able to perform at least one correct repetition than for P1. However, its slow execution requires more time required to support the trunk in relation to P1 and, because of this, requires good conditioning of the abdominal musculature. It has also been shown that P2 is easier to perform than P1 because of the more comfortable position of the arms and greater hip stability, which together do not interfere with the distance traveled by the hands during the exercise[22]. It also allows for a number of people to be evaluated simultaneously due to the use of the metronome. On the other hand, by controlling the number of repetitions through the metronome (20 per minute), P2 can become long, exhausting, and demotivating, and this should be considered as a possible limiting factor for the application of this test in the elderly. Despite the advantages of P2, another drawback noted was the lack of coordination and rhythm regarding the use of the metronome. The maintenance of the rhythm of movement depends on the integration of the central commands and neuromuscular coordination, particularly of muscle strength and the reaction time[23]. With aging, there is an increase in motor response time resulting from structural and functional modifications of the organism, altering the integrity of the central nervous system, contributing to slower reactions as the person ages. This decline in sensory functions along with the lack of an adequate time of practice with the instrument (metronome) were probably factors that interfered with the results.

In this study, a higher performance was expected on P2 than on P1, but this was not observed. The explanation for this may be the duration of the test, as mentioned earlier. In comparison to younger people, the elderly need to activate a higher percentage of their reduced muscle mass to generate the same force that allows them to perform and sustain exercises that must be performed with a certain intensity and time[24]. By requiring higher percentages of maximal exercise capacity, muscle fatigue can occur early in response to increased metabolic stress and decreased ability of the neuromuscular system to generate strength, work, or power during repeated muscle contractions[25]. In addition, localized muscle endurance work requires that a specific muscle group maintain the same strength level for a longer period of time, and in that case, the motivation factor may influence performance on tests aimed at assessing physical aspects. Motivation is an important factor in activities and sports that require high muscular and metabolic activity[26].

In addition to the characteristics of each test mentioned above, other aspects that could interfere with the results relate to the degree of prior engagement in physical activity and level of physical fitness of the participants, their lack of familiarity with the tests, difficulties in coordination of movements, and difficulty following the test rhythm dictated by the metronome, among others.

When compared to each other, the two tests did not present statistically significant differences for RPE, perception of abdominal effort, or perception of pain in the cervical and lumbar region (Table 3), suggesting that despite some inadequate performances, with some adaptations they could be used in women 55+ years for the purpose of abdominal muscle testing. Regarding pains in the cervical and lumbar region, it can be said that both tests are satisfactory, since the frequency at which these symptoms appeared was low, in spite of greater reports of discomfort in P1.

In regard to effort, evaluated through RPE, both tests are applicable, since values between 12 and 13 correspond to a low level of difficulty and cardiorespiratory overload[15]. The low level of perception of reported abdominal effort may be related to the low activation of the abdominal musculature; however, it is important to mention that each test implies a different perception of effort, because the SPE reflects exercise fatigue in a different way[27,28], that is, being more sensitive in the active muscles during the performance of power exercises than in central fatigue during the performance of resistance exercises[29].

Regarding the relationship between performance on the tests with anthropometric parameters and flexibility, there was also no significant difference between them (Table 4). For BMI and waist-to-hip ratio, there was a tendency for an inverse correlation. This trend indicates that overweight women may be at risk of poor performance[30], as well as limiting their involvement in structured physical activities, with a consequent reduction in muscle strength. Similarly, body weight was another variable that did not demonstrate a significant correlation with performance in both protocols. This finding suggests that, for the evaluated group, body weight does not present as a mechanical barrier to the performance of women 55+ years of age on the tests evaluated.

In this study, excess body weight may also be one of the determining factors for the low abdominal exercise performance and, even though the BMI did not present statistical significance (Table 4), it was inversely proportional to the performance of the participants. Even so, it is assumed that the increase in body mass, represented by the fat component, tends to restrict engagement in physical exercises, especially those that require strength and thus reduces muscular fitness and coordination for more complex exercises.

Flexibility did not demonstrate a statistically significant correlation with performance in the abdominal tests used, suggesting that it did not influence performance. In relation to flexibility, the range of motion of the joint decreases considerably with age, limiting the motion and function of the elderly. A decrease in flexibility along with shortening of the hip flexor muscle and extensor muscles of the back may result in additional mechanical stress on the joints and soft tissues of the lumbar spine and may cause lordosis. Thus, the deep abdominal muscles are essential to support the lumbar spine and strengthening these muscles can reduce back pain[31].

Weakening of the abdominal muscles, along with ptosis of the abdomen and shortening of the anteversory muscles of the pelvis, are factors directly related to the degree of flexibility of the lumbar spine and, consequently, directly related to low back pain. This imbalance may limit spinal movements due to impaired levels of adequate flexibility or pain caused by postural deviations. In people with reduced mobility in the articulations of the spine or with shortening of the extensors of the spine, contraction of the abdominal muscles will exert a greater compression force on the intervertebral discs than in individuals with good spine flexibility[31]. This limitation may interfere with the performance of certain exercises, such as performing trunk flexion during abdominal exercises.

Thus, based on the main findings of this study, we concluded that both abdominal tests evaluated seem to be adequate for women 55+ years, despite the difficulty most of the participants had in performing correct executions, and that anthropometric variables and flexibility did not seem to directly influence the performance.

However, despite the relevance of the results, the present study has some limitations: 1) the use of the same volunteers to carry out the two assessment protocols was a potential limitation. However, this option minimized inter-subject variability; 2) The use of only trained women 55+ years old, which prevents the generalization of the results found here for other populations (for example, men, untrained women, older adults); 3) The use of simple anthropometric measures can also be considered a limitation of the study, since anthropometry has low sensitivity and high variation[32]. Nonetheless, the use of simple anthropometric measures can increase the ecological validity, and to be applied for different professionals involved with exercise prescription.

Conclusion

Based on the results obtained, it was possible to conclude that both abdominal test protocols were adequate for the sample studied, since they did not present statistically significant differences for performance or perception of pain in the cervical and lumbar region.

Variables such as BMI, body weight, hip waist ratio, and flexibility do not seem to interfere with their performance, at least for the population investigated. In addition, the internal load imposed by the abdominal test protocols, evaluated through SPE, remained within physiological limits, showing that both are safe from the point of view of perceived exertion. On the other hand, the abdominal musculature, evaluated by a perception scale constructed for this study, also did not show any statistically significant results.

Finally, the results indicated that the use of the abdominal test as part of the assessment of musculoskeletal fitness in women 55+ years old proved to be safe, easy to apply, and suitable for this subjects.

Conflict of interest

The authors do not declare a conflict of interest.

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Analysis of changes in heart rate variability before and after a table tennis match depending on the outcome

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Fatigue. Table tennis. Autonomous nervous system. Competition. Performance

Summary

The aim of this study was to compare heart rate variability (HRV) indices before and after a table tennis match, depending in match result. HRV indices were measured before (PRE) and after (POST) match periods to 21 table tennis players (21.86 ± 8.34 yr) in 30 matches. No significant differences were found neither in PRE nor in POST measures comparing winners and losers. A significantly lower value ($p < 0.05$) was found in mean of RR intervals (mean RR), standard deviation of RR intervals (SDNN), the natural logarithm transform of the root mean square of successive differences between normal heartbeats (LnRMSSD), relative number of successive RR interval pairs that differ more than 50 ms (pNN50), cross (SD1) and longitudinal (SD2) axis of Poincaré plot comparing POST values with PRE values. Nevertheless, low frequency index expressed in absolute power (LF Power) and high frequency indices expressed in absolute power (HF power) and normalised power (HF Power) showed different trends depending on the results ($p < 0.05$). The obtained results show a HRV decrease after table tennis match regardless the match result, in both time domain and non-linear indices. However, frequency domain indices show a different trend depending on the match outcome.

Análisis de la evolución de la variabilidad de la frecuencia cardíaca antes y después de un partido de tenis de mesa en función del resultado

Resumen

El objetivo del estudio fue analizar el comportamiento de la variabilidad de la frecuencia cardíaca (VFC) de jugadores de tenis de mesa antes y después de un partido ateniendo al resultado (ganar o perder). Se midió la VFC antes (PRE) y después (POST) del partido a 21 jugadores de tenis de mesa en un total de 30 partidos. No se observaron diferencias significativas ni en el PRE ni en el POST en función del resultado. Se observó un descenso ($p < 0,05$) en la media de los intervalos RR (media RR), la desviación estándar de los intervalos R-R (SDNN), el logaritmo natural de la raíz cuadrada del valor medio de la suma de las diferencias al cuadrado de todos los intervalos R-R (LnRMSSD), el porcentaje de los intervalos RR consecutivos que discrepan en más de 50 ms entre sí (pNN50), el eje transversal (SD1) y longitudinal (SD2) del diagrama de Poincaré en el POST con respecto al PRE en ambos grupos. Sin embargo, las variables de la banda de baja frecuencia expresada en fuerza absoluta (LF Power), la banda de alta frecuencia expresadas en fuerza absoluta (HF Power) y fuerza normalizada (HF Power) mostraron tendencias distintas en función del resultado ($p < 0,05$). Los resultados muestran un descenso en la VFC después de disputar un partido de tenis de mesa independientemente del resultado del partido en el dominio del tiempo y en variables no lineales. No obstante, el dominio de la frecuencia muestra una tendencia distinta en función del resultado.

Palabras clave:
Fatiga. Tenis de mesa. Sistema nervioso autónomo. Competición. Rendimiento.

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Introduction

Table tennis is an intermittent racket sport, alternating short cycles of high-intensity effort with incomplete recovery periods[1–3]. Due to the demands of competition, table tennis is considered a mixed sport, with a continuous use of both the aerobic and anaerobic systems[4]. The aerobic system is the main source of energy during matches, allowing adequate recovery during interruptions that occur during the game[2,3]. On the other hand, due to the continuous high-intensity actions that occur during matches, the anaerobic system is essential in periods of exertion[2,3]. In addition to the related physical demands, table tennis is characterized by requiring athletes to perform, different technical actions—in a coordinated manner and at maximum speed—with the upper limbs after having made short and fast displacements with continuous changes of direction[2]. At the same time, players must deploy a large repertoire of movements to select the correct shot as quickly as possible based on their opponent's actions[5]. In addition to the high physical demands, continuous tactical decisions, and the need to accurately execute different technical actions, players are also subject to a high cognitive demand and a high level of mental stress[6]. This form of sport is, therefore, one with high physical and psychological demands[2,6].

Previous studies have shown that both physical and psychological demands affect the state of the autonomic nervous system (ANS)[7]. During exercise, increases in intensity entail increases in sympathetic activity and decreased parasympathetic activity, resulting in an increased heart rate (HR)[8,9]. Heart rate variability (HRV) has been used to understand the activation of the ANS, both in individual and collective sports[10,11]. HRV is a non-invasive tool that shows the variation in the time elapsed between successive beats by analyzing R-R intervals, thereby allowing an analysis of ANS activity and, thus, showing the activation level of the sympathetic and parasympathetic nervous system[12,13]. In this sense, HRV analysis allows one to observe the response of the ANS in different exercise situations[9,14]. The variables used to measure HRV are based on time-domain, frequency-domain, and non-linear variables[15]. The parameters commonly used in time-domain analysis are the square root of the mean squared difference of all successive R-R intervals (RMSSD) and the standard deviation of consecutive R-R periods (SDNN)[16]. These variables analyze HR variations, owing to which they depend on it[15]. To isolate the analysis of HRV for each participant's HR, and thus to be able to compare different situations independently of the HR, the natural log-transformed root mean square of successive R-R intervals (LnRMSSD)[17] was used. On the other hand, frequency-domain analysis breaks down the R-R signal into different components, thus showing: i) the high frequency band (HF), which shows parasympathetic nervous system activity, ii) the low frequency band (LF), affected by both the sympathetic and parasympathetic nervous system and iii) the LF/HF ratio, which reflects sympathetic dominance when it has a high value[17]. However, it has previously been observed that breathing patterns affect frequency-domain values, which makes it difficult to interpret results[7,18]. In addition, analyses with non-linear HRV parameters show parasympathetic modulation without the involvement of breathing[19]. Specifically, the parameters used are SD1, which reflects parasympathetic activity in the heart, and SD2, which reflects both sympathetic and parasympathetic activity[20].

In light of the information obtained on ANS activation, HRV has been researched in different training and competition situations in individual and collective sports[8,9,21,22]. Several studies have analyzed HRV variation before and after different physical exertion with the aim of assessing the influence of physical activity on HRV[9,17,22,23]. Specifically, in badminton players, a sport similar in structure to table tennis, decreased post-exercise values of SDNN and RMSSD have been observed in comparison to pre-exercise values, thus showing an increase in the activity of the sympathetic nervous system induced by accumulated effort[8,22,24]. In addition, a recent study—also with badminton players—analyzed pre-post competition HRV based on competitive outcome (win or lose), to observe whether the competitive outcome could affect changes in HRV[25]. In that study, it was observed that the players who won the match had higher values in the LF/ HF ratio and a lower magnitude of the HF and LF variables than the losing players, thus showing a greater sympathetic activation of the ANS in the winners. However, no significant differences were obtained in time-domain parameters or non-linear variables. Despite the significance of possible changes in HRV before and after playing a table tennis match according to the outcome, there are no studies that analyze this aspect. This analysis would provide more exhaustive knowledge of competitive demand and the behavior of the ANS in table tennis as relates to winning or losing the match, since the match's outcome seems to affect the HRV[25].

Therefore, the objectives of the present study were, firstly, to analyze the HRV behavior of table tennis players before and after playing a match according to their outcomes (win or lose) and, secondly, to analyze if match duration affects HRV.

Materials and method

Participants

The sample was composed of 21 table tennis players (21.86 ± 8.34 years, 1.73 ± 0.08 m, 64.09 ± 13.39 kg and 21.46 ± 4.38 kg·m^{-2}), who competed in one of the official categories of table tennis, both nationally and provincially in the autonomous community of the Basque Country. The criteria for inclusion in the study were to have a valid license issued by the Spanish Table Tennis Federation and not to be injured or recovering from an injury at the time of the research study. All participants had at least two years' experience in table tennis competitions. All were informed of the objectives and procedures of the research study and voluntarily agreed to be part of it, signing an informed consent form. In the case of underaged players, the informed consent form was also signed by their parents or legal guardians. The study was conducted with the consent of the club to which they belonged. All procedures followed the guidelines set out by the Declaration of Helsinki (2013), respecting the provisions of the Organic Law on the Protection of Personal Data (LOPDCP). Likewise, the study was approved by the Ethics Committee for Research with Human Beings (CEISH, Nº 2080310018-INB0059) of the University of the Basque Country (UPV/EHU).

Procedure

We analyzed 30 best-of-5 table tennis matches played outside the competitive season, thereby obtaining 60 records. In each of the matches, the outcome obtained by the players (win or lose) was noted. The participants' HRV was measured before and after the matches. The HRV was recorded for 8 minutes PRE and POST match, taking into account the last 3 minutes PRE and the first 3 minutes POST. Each participant was instructed to lie on their backs for 8 minutes before[26,27] and after the match[8,9,23,28]. Pre-match logs were made before the 2-minute warm-up and POST match logs were made immediately after the end of the match. A warm-up was carried out prior to each match, which consisted of 2 minutes of forehand and backhand exchanges, including topspin hitting.

Measurement

HRV analysis: The heart rate signal was measured using a chest band with Bluetooth Smartyse technology, which was recorded on a Polar monitor (V800, Kempele, Finland). The data obtained were transferred to a computer using a specific software (Polar Flow, Kempele, Finland) and were exported for HRV analysis using the Kubios v3.0 software (Biosignal Analysis and Medical Imaging Group at the Department of Applied Physics, University of Kuopio, Kuopio, Finland).

The time-domain parameters obtained were the following: i) the mean R-R interval (Mean RR), ii) the standard deviation of the R-R intervals (SDNN) which describes both alterations in the sympathetic and parasympathetic system; (iii) the mean heart rate (Mean HR); (iv) standard deviation of heart rate (STD HR); (v) the minimum recorded heart rate (Min HR); vi) the maximum recorded heart rate (Max HR); vii) log-transformed root mean square of successive R-R intervals (LnRMSSD), which reflects the variance between HR beats and estimates vagal changes ; and viii) the percentage of successive R-R intervals more than 50 milliseconds apart (pNN50), which has been observed to correlate with changes in the parasympathetic nervous system and RMSSD[29]. The above parameters quantify the amount of HRV observed in the monitoring periods[29].

In regard to frequency-domain parameters, which show the contribution of both the sympathetic and parasympathetic nervous systems, the following were recorded: i) power peaks between 0.04-0.15 Hz (Low frequency (LF)), ii) power peaks between 0.15-0.40 Hz (High frequency (HF)) and iii) the ratio between LF and HF (LF/LF), high values of which are associated with the sympathetic system domain[17]. These values analyze the frequency with which the distance of the R-R interval changes[17], drawing measurements in three different units; i) absolute force (ms2); (ii) logarithmic force (log) (iii) normalized force (u.n.).

The following non-linear parameters were analyzed: i) the transverse axis of the Poincaré diagram (SD1), which analyzes HRV in the short term and is an indicator of sympathetic activity[29]; ii) the longitudinal axis of the Poincaré diagram (SD2), which analyzes HRV in the long term, correlates with LF, and is an indicator of parasympathetic activity[29]; and iii) the SD2/SD1 ratio used to analyze autonomous balance and the balance between sympathetic and parasympathetic activity[29].

Statistical analysis

The results are shown in mean and standard deviation (SD). Data standardization was analyzed using the Shapiro-Wilk test, observing that the data did not display a normal distribution. The Mann-Whitney U test was used to analyze the differences between players who won and those who lost at both pre and post times. On the other hand, the Wilcoxon test was used to analyze independent differences between the PRE match and POST match values in each of the groups. The percentage difference (Δ. %) was calculated in each case using the following formula: Δ. (%) = [(mean POST – mean PRE) / mean PRE] x 100. The effect size (ES) was calculated both for the differences between groups at each moment and for the differences between the PRE and POST in each of the groups[30]. Effect sizes less than 0.2, between 0.2 and 0.5, between 0.5 and 0.8 and above 0.8 were considered trivial, low, moderate and high, respectively. The relationship between the duration of the matches and the different HRV variables was analyzed using the Spearman correlation coefficient (r). The correlations obtained were considered high when the absolute value was between 1 and 0.70, moderate between 0.69 and 0.50, low between 0.49 and 0.20, and very low between 0.19 and 0.0931. Statistical significance was established at $p < 0.05$. Statistical analysis was performed with the Statistical Package for Social Sciences program (version 23.0, SPSS® Inc. Chicago, IL, USA).

Results

Table 1 shows the results obtained for the HRV time-domain values in the PRE match and POST match, by both the players who won and lost the match. Neither the PRE values nor the POST values of any of the HRV time-domain variables showed significant differences between the players who won the match and those who lost ($p > 0.05$, ES = -0.4 to 0.28, low). The mean parameters RR, SDNN, LnRMSSD and pNN50 showed a significant decrease in the POST match with respect to the PRE ($p < 0.05$, ES = -0.44 to -2.26, moderate to high) both in the group of players who won and those who lost the match. However, Mean HR, Min HR, and Max HR showed a significant increase in the POST match with respect to the PRE ($p < 0.05$, ES = 1.25 to 1.7, high) in both groups. No significant differences were observed between PRE and POST in the STD HR variable in either group ($p > 0.05$, ES = 0.1 to 0.12, trivial).

Table 2 shows the HRV frequency-domain values obtained by both the players who won and those who lost the match, in the PRE and POST match. Neither the PRE values nor the POST values of any

Table 1. Descriptive parameters of heart rate variability in the pre-match (PRE) and post-match (POST) time domain, categorized by match outcome (win or lose).

		PRE	POST	Δ. (%)	ES
Average RR (ms)	WIN	784.81 ± 126.01	591.59 ± 90.04**	-24.62	-2.15
	LOSE	771.68 ± 125.02	574.96 ± 87.12**	-25.49	-2.26
	Δ. (%)	-1.67	-2.81		
	ES	-0.11	-0.19		
SDNN (ms)	WIN	41.48 ± 16.47	31.97 ± 21.76**	-22.92	-0.44
	LOSE	38.79 ± 12.96	29.23 ± 20.64**	-24.64	-0.46
	Δ. (%)	-6.49	-8.57		
	ES	-0.21	-0.13		
Mean HR (beats/min)	WIN	78.12 ± 11.06	103.60 ± 15.02**	32.62	1.7
	LOSE	79.49 ± 11.39	106.85 ± 17.54**	34.42	1.56
	Δ. (%)	1.75	3.13		
	ES	0.12	0.18		
STD HR (beats/min)	WIN	5.38 ± 2.34	5.89 ± 4.09	9.44	0.12
	LOSE	5.29 ± 1.49	5.62 ± 3.21	6.24	0.1
	Δ. (%)	-1.78	-4.65		
	ES	-0.06	-0.09		
Min HR (beats/min)	WIN	66.34 ± 7.32	85.48 ± 12.13**	28.86	1.58
	LOSE	68.17 ± 10.15	89.84 ± 17.31**	31.8	1.25
	Δ. (%)	2.76	5.1		
	ES	0.18	0.25		
Max HR (beats/min)	WIN	93.93 ± 16.86	131.42 ± 23.86**	39.91	1.57
	LOSE	96.27 ± 14.04	138.08 ± 24.12**	43.44	1.73
	Δ. (%)	2.48	5.07		
	ES	0.17	0.28		
LnRMSSD (ms)	WIN	3.37 ± 0.56	2.92 ± 0.75**	-13.31	-0.6
	LOSE	3.25 ± 0.46	2.75 ± 0.71**	-15.33	-0.71
	Δ. (%)	-3.43	-5.69		
	ES	-0.25	-0.24		
pNN50 (%)	WIN	12.36 ± 16.75	6.21 ± 11.73**	-49.78	-0.52
	LOSE	8.75 ± 11.16	3.13 ± 7.72**	-64.27	-0.73
	Δ. (%)	-29.16	-49.61		
	ES	-0.32	-0.4		

Mean RR: Mean of the R-R interval; SDNN: Standard deviation of R-R intervals; Mean HR: Mean heart rate; STD HR: Standard deviation of heart rate; Min HR: Minimum heart rate; Max HR: Maximum heart rate; LnRMSSD: log-transformed root mean square of successive R-R intervals; pNN50: Percentage of successive R-R intervals that exceed more than 50 milliseconds with each other; ES: Effect size; Δ. (%): Percentage of variation.

**$p < 0.01$ significant differences with respect to the PRE.

of the frequency-domain variables showed significant differences between the players who won the match and those who lost ($p > 0.05$, ES = -0.66 to 0.53, moderate). The variables LF Power (log) and HF Power (log) showed a significant decrease in the POST with respect to the PRE split values ($p < 0.05$, ES = -0.43 to -0.82, moderate to high) in both the players who won and those who lost the match. However, the LF Power (ms2), HF Power (ms2) and HF Power (u.n.) displayed a different trend in both groups. While the LF Power (ms2) in the group that won the match decreased significantly in the POST with respect to the PRE ($p < 0.05$, ES = -0.45, moderate), it increased significantly ($p < 0.05$, ES = 0.02, trivial) for the players who lost the match. As for HF Power (ms2) and HF Power (u.n.), no significant changes were observed in the POST match with respect to the PRE match in the group that won ($p > 0.05$, ES = -0.03 to 0.07, trivial), while the group that lost the match displayed a significant decrease ($p < 0.05$, ES = -0.18 to -0.51, trivial to moderate). With respect to LF Power (u.n.) no significant changes were observed between the PRE and the POST match in the group that won ($p > 0.05$, ES = 0.03, trivial), while the group that lost the match displayed a significant increase

Table 2. Descriptive parameters of heart rate variability in the pre-match (PRE) and post-match (POST) frequency domain, categorized by match outcome (win or lose).

		PRE	POST	Δ. (%)	ES
LF Power (ms^2)	WIN	1250.28 ± 1263.59	756.09 ± 1099.08**	-39.53	-0.45
	LOSE	948.03 ± 836.46	998.96 ± 2500.83**	5.37	0.02
	Δ. (%)	-24.17	32.12		
	ES	-0.36	0.1		
LF Power (log)	WIN	6.74 ± 0.89	6.06 ± 1.02**	-10.15	-0.67
	LOSE	6.55 ± 0.78	5.69 ± 1.54**	-13.22	-0.56
	Δ. (%)	-2.86	-6.18		
	ES	-0.25	-0.24		
LF Power (u.n.)	WIN	68.02 ± 15.03	68.49 ± 18.78	0.69	0.03
	LOSE	68.79 ± 14.47	76.19 ± 14.53**	10.76	0.51
	Δ. (%)	1.12	11.24		
	ES	0.05	0.53		
HF Power (ms^2)	WIN	657.82 ± 935.46	816.72 ± 2431.46	24.16	0.07
	LOSE	439.21 ± 487.93	297.09 ± 789.74**	-32.36	-0.18
	Δ. (%)	-33.23	-63.62		
	ES	-0.45	-0.66		
HF Power (log)	WIN	5.87 ± 1.03	5.17 ± 1.63**	-12.01	-0.43
	LOSE	5.66 ± 0.88	4.36 ± 1.58**	-22.95	-0.82
	Δ. (%)	-3.68	-15.65		
	ES	-0.25	-0.51		
HF Power (u.n.)	WIN	31.91 ± 14.99	31.44 ± 18.76	-1.49	-0.03
	LOSE	31.13 ± 14.44	23.71 ± 14.45**	-23.83	-0.51
	Δ. (%)	-2.45	-24.58		
	ES	-0.05	-0.53		
LF/HF Power (ms2)	WIN	3.32 ± 2.51	3.03 ± 1.63	-8.72	-0.18
	LOSE	4.06 ± 2.89	3.78 ± 2.69	-6.67	-0.1
	Δ. (%)	22.31	24.93		
	ES	0.26	0.28		

LF: Low frequency; HF: High frequency; LF/HF: Ratio between LF and HF; Power (ms2): Absolute force; Power (log): Logarithmic force; Power (u.n.): Normalized force; ES: Effect size; Δ. (%): Percentage of variation.
**p < 0.01 significant differences with respect to the PRE.

($p < 0.05$, ES = 0.51, moderate). No significant differences were observed between PRE and POST in either group in the variable LF/HF Power (ms2) ($p > 0.05$, ES = -0.1 to -0.18, trivial).

Table 3 shows the results obtained by both the players who won the match and those who lost in the PRE match and POST match in terms of the non-linear HRV values. Neither the PRE values nor the POST values of any of the non-linear variables showed significant differences when comparing the players who won the match with those who lost ($p > 0.05$, ES = -0.37 to 0.2, trivial to low). SD1 and SD2 showed a significant decrease in the POST with respect to the PRE ($p < 0.05$, ES = -0.38 to -0.48, low) in both the players who won and lost the match. No difference was observed between PRE and POST in either group in SD2/SD1 ($p > 0.05$, SD = 0.24 to 0.28, low).

There was no significant association between match duration and HRV variables in either PRE or POST match in any of the groups. Significant correlations were only found between match duration and Δ. (%) Min HR in the group that won ($r = 0.375$, $p < 0.05$) and in the group that lost the match ($r = 0.479$, $p < 0.01$).

Discussion

The objective of this study was to analyze the HRV behavior of table tennis players before and after playing a match, taking into account the outcome (win or lose). HRV is a useful and non-invasive tool that allows one to analyze the behavior of the ANS[12,32] and has previously been used to analyze over-training states, to better gauge adjustments to training,

Table 3. Descriptive parameters of heart rate variability in the non-linear pre-match (PRE) and post-match (POST) domain, categorized by match outcome (win or lose).

		PRE	POST	Δ. (%)	ES
Poincaré Plot, SD1	WIN	24.47 ± 17.16	17.85 ± 17.47**	-27.05	-0.38
	LOSE	20.45 ± 10.95	14.43 ± 12.55**	-29.46	-0.48
	Δ. (%)	-16.41	-19.17		
	ES	-0.37	-0.27		
Poincaré Plot, SD2	WIN	52.48 ± 18.41	40.96 ± 26.06**	-21.95	-0.44
	LOSE	50.45 ± 16.12	37.73 ± 26.60**	-25.21	-0.48
	Δ. (%)	-3.87	-7.88		
	ES	-0.13	-0.12		
Poincaré Plot, SD2/SD1	WIN	2.60 ± 1.01	2.86 ± 0.94	10.04	0.28
	LOSE	2.79 ± 0.92	3.05 ± 1.10	9.34	0.24
	Δ. (%)	7.1	6.43		
	ES	0.2	0.17		

SD1: Cross-sectional axis of the Poincaré plot; SD2: Longitudinal axis of the Poincaré plot; SD2/SD1: Ratio between SD1 and SD2; ES: Effect size; Δ. (%): Percentage of variation.
**$p < 0.01$ significant differences with respect to the PRE.

and to quantify the level of pre-competitive stress[23,33,34]. These aspects allow for one to more adequately plan training strategies to improve sports performance. Although HRV analysis has previously also been used to compare pre- and post-match values in various sports[9,21,35] and also in racket sports such as badminton[8,22], this type of analysis has not been performed on table tennis players. In addition, the present work is the first study in which the changes in HRV before and after playing a match has been analyzed based on the sports outcome (win or lose) in table tennis, having found only one study in this line in badminton[25]. Analyzing HRV before and after matches makes it possible to observe changes in the sympathetic-parasympathetic balance, thus showing the athlete's state of fatigue[9]. Moreover, the differentiated analysis depending on the outcome may be relevant because winning or losing the match can generate different levels of fatigue, thus affecting the activation of the ANS[25]. In this sense, this analysis provides more exhaustive knowledge of competitive demand in a differentiated way between those who win and lose the game.

HRV time-domain variables have been used in other racket sports, such as badminton, to analyze post-match fatigue[8,22,24], showing a decrease in the values of SDNN and pNN50, while an increase in HR variables is observed, possibly related to increased fatigue[17]. The results of this study showed a decrease in the mean RR, SDNN, LnRMSSD and pNN50 of the POST values with respect to the PRE values, both in the players who won and in those who lost the match. On the contrary, there was an increase in the mean HR, Min HR and Max HR in the POST with respect to the PRE in both groups. These results coincide with those obtained in previous studies[8,24,36], which showed a decrease in time-domain variables and an increase in HR variables, associated with an increase in competitive fatigue. In addition, this research provides differentiated information as it takes into account the match outcome. In this way, it coincides with the results obtained in a previous study carried out with badminton players[25]. Those authors found decreases in time-domain variables of the POST values with respect to the PRE in badminton matches, both in the players who won and in those who lost, without finding significant differences between the groups[25]. Those results coincide with those obtained in the present study since the HRV time-domain variables showed no differences between the winners and losers in their change in HRV between PRE and POST. The results obtained suggest that the level of fatigue may have been similar in both groups. The absence of differences in changing HRV between the winning and losing players may be due to the fact that the matches that were analyzed were played between players of similar levels, with very tight scores and high competitive demand until the end of the matches. Therefore, it could be interesting in future studies to analyze whether the change in HRV may be associated with the burden of competition and whether the competitive burden is different for winning or losing players.

The frequency-domain variables break down the strength of the RR signal into different frequency components, thus showing the state of the autonomic nervous system[15]. Although the analysis of frequency-domain variables has previously been used in other sports to analyze post-match fatigue[21,24,25,35], it has not been used previously in table tennis. The results obtained in the present study showed a decrease in the LF Power (log) and HF Power (log) as relates to POST vs. PRE values, both in the players who won and in those who lost the match. These results are partially consistent with previous studies in badminton[24,25], rugby[21], basketball and football[35]. In badminton players, decreases were found in HF Power (%) comparing pre- and post-match values, but this difference was not obtained in LF Power (%)[24,25]. On the other hand, in rugby[21], basketball and football[35] players, although they did not differentiate between players who won and lost matches, a decrease was obtained in the post as compared to pre-exercise in both LF and HF, thus showing an exercise-induced activation of the sympathetic nervous system. Likewise, in the present study, no significant changes were observed between the pre- and post-match values in the LF/HF variable in either group. However, previous studies found a significant increase in this variable in badminton players[24,25], football or basketball players[35] and athletes[36], thus showing a greater activation of the sympathetic system after competition as compared to pre-competition values. One of the main novelties of this study is that it analyzes the change in HRV in a differentiated way according to the match outcome (win or lose) in table tennis. The results obtained suggest that the variables LF Power (ms2), HF Power (ms2), HF Power (u.n.) and LF Power (u.n.) displayed different trends depending on the match outcome. In the group that won the match, decreases were observed in the variable LF Power (ms2), while the variable HF Power (ms2) increased and the variables LF Power (u.n.) and HF Power (u.n.) did not vary, when comparing the PRE and POST match values. On the other hand, in the group that lost the match it was observed that the variables HF Power (ms2) and HF Power (u.n.) decreased, while the variables LF Power (ms2) and LF Power (u.n.) increased, when comparing the values before and after the match. These results do not coincide with the results obtained in a similar study conducted with badminton players[25], in which they observed the same pre-post trends in both players who won and those who lost the match. The only exception to this was for the variable LF Power (%), which despite having non-significant pre-post differences, displayed a decrease in the group that won while an increase was observed in the group that lost the match. As previous studies indicate[7,18], it is possible that these contradictory results are due, on the one hand, to the fact that frequency-domain values may be affected by breathing patterns, which were not monitored in this study, and on the other hand, to the fact that the type of exercise performed may affect frequency-domain variables[34], as well as the athlete's attention, stress or mood[7,25]. In this sense, as indicated by other studies[18], it is recommended that HRV be analyzed using time-domain or non-linear measurements, since they provide data that is unaffected by breathing patterns. For future research, it would be advisable to analyze aspects such as stress management or breathing in order to know how they affect frequency-domain values depending on match outcome.

As mentioned above, the non-linear HRV variables show parasympathetic modulation without the involvement of respiration[19]. Non-linear methods have been used previously in other sports as a fatigue analysis tool[8,22,24,25]. The results of this study show a significant decrease between PRE and POST in SD1 and SD2 in both players who won and those who lost the match. These results are consistent with studies carried out previously in other racket sports such as badminton[8,22,24,25], in which there is an increase in sympathetic activity and a reduction in parasympathetic activity at the end of the match with respect to the beginning. However, contrary to the results obtained in the frequency-domain variables, there were no differences in the non-linear variables between the players who won and those who lost, which coincides with the results of a previous study carried out with badminton players[25]. These differences in the trends observed between frequency-domain variable values and non-linear HRV variables may be due to the fact that in non-linear methods the breathing patterns do not affect the results obtained[7,18,25], while respiration can affect frequency-domain variables.

Although previous researchers observed that the duration and time of the exercise session directly affect HRV[7], mainly due to the activation of the sympathetic system and decreased activity of the parasympathetic nervous system, there is controversy in this regard. Contrary to the results presented in previous studies[7], a study conducted with long-distance runners showed that HRV immediately after exercise was not related to exercise duration[37]. However, those authors explained that the higher the intensity of the exercise, the longer it took for the post-exercise HRV values to return to baseline[37]. In the present study, with the exception of Min HR, no significant correlations were found between HRV variables and the duration of the table tennis match in either the group of players who won or lost the match. The absence of a significant association between match duration and HRV parameters obtained in this study seems to confirm the conclusions obtained in previous studies[37,38], which state that, both in continuous and intermittent exercise, HRV may be influenced to a greater extent by the intensity of the exercise than by its duration. Therefore, in future studies it would be interesting to control changes in HRV and also to quantify the intensity of matches to analyze any possible associations between both variables.

The main limitation of this study is the absence of previous research with which to compare the results obtained. It was only possible to compare the pre- and post-match differences in HRV depending on the competitive outcome with badminton. Nor have we found any study that analyzed HRV in table tennis players, making it necessary to compare the results obtained with other similar sports such as badminton and other less similar ones such as football, basketball or rugby. On the other hand, the results were obtained through simulated matches, so it is possible that, in a real competition, psychological stress, among other factors, could affect HRV behavior in different ways. It would be desirable for future studies to analyze whether HRV varies depending on the match outcome in official competitions, monitoring other variables that affect HRV such as match intensity, quality of sleep, or competitive stress.

Conclusions

As observed in this study, there was a decrease in HRV after playing a simulated table tennis match owing to the effort exerted, regardless of the outcome of the match. However, despite the fact that decreases were observed in both the time-domain variables and the non-linear variables in both groups, there was no trend in the frequency-domain variables, possibly due to the effect of respiration in these variables. On the other hand, the results obtained in the present study seem to show that there is no relationship between the duration of the table tennis match and HRV.

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Conflict of interest

The authors do not declare any conflict of interest.

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Differences in internal and external load between adult and youth soccer players in a friendly match

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Summary

Objective: To determine differences in internal and external load during an unofficial match between First Division Adult and U-19 players of the same club using portable global positioning systems.
Methods: During an unofficial match between an adult and a U-19 category, internal load through heart rate and external load through running performance were monitored. Seven adult players (25.57 ± 5.06 years) and five U-19 players (18.6 ± 0.54 years) were monitored. Comparisons were made between categories in the first half, second half and total match using the Mann-Whitney U test and calculating effect sizes through percent difference (PD).
Results: Differences were found ($p<0.05$) of external load in maximum speed in first half and total match, with U-19 players reaching the highest values (maximum speed first half: 32.34 vs 27.77 km/h and PD = 15.3%; total match: 32.6 vs 28.14 km/h and PD = 14.7%). On the other hand, differences in internal load were only found in heart rate zone 3 (70 to 80% of maximum HR) in the first and second half, where U-19 players spent more time in this zone (heart rate zone 3 first half: 6.1 vs 1.73 minutes and PD = 111.6%; second half: 20.49 vs 5.21 minutes and PD = 118.8%). No differences were found in the other variables analyzed.
Conclusion: From the results obtained we can conclude that there are no differences in internal and external load in adult players with U-19 players, except for maximum speed and heart rate zone 3 in this team during a non-official match. Therefore, for practical purposes, the U-19 players of this team could be in conditions to face the physical demands required by the adult category competition.

Key words:
Sports. Heart rate. Soccer. Physiologic monitoring.

Diferencias de carga interna y externa entre futbolistas adultos y juveniles en un partido amistoso

Resumen

Objetivo: Determinar diferencias de carga interna y externa durante un partido no-oficial entre jugadores de Primera División Adultos y Sub-19 del mismo club empleando sistemas portátiles de posicionamiento global.
Método: Durante un partido no-oficial entre una categoría Adulta y una Sub-19, se monitoreó la carga interna a través de la frecuencia cardíaca y carga externa a través del rendimiento de carrera. Se monitorearon a siete jugadores adultos (25,57 ± 5,06 años) y cinco jugadores Sub-19 (18,6 ± 0,54 años). Se realizaron comparaciones entre las categorías en el primer tiempo, segundo tiempo y partido total mediante la prueba U de Mann-Whitney y calculando los tamaños del efecto a través de porcentajes de diferencia (PD).
Resultados: Se encontraron diferencias ($p<0,05$) de carga externa en velocidad máxima en primer tiempo y partido total, alcanzando los jugadores Sub-19 los valores más elevados (velocidad máxima primer tiempo: 32,34 *vs* 27,77 km/h y PD = 15,3%; partido total: 32,6 vs 28,14 km/h y PD = 14,7%). Por otro lado, solo se hallaron diferencias en carga interna en zona 3 de frecuencia cardíaca (70 a 80% de la FC máxima) en primer y segundo tiempo, donde los jugadores Sub-19 pasaron más tiempo en esta zona (zona 3 de frecuencia cardiaca primer tiempo: 6,1 *vs* 1,73 minutos y PD = 111,6%; segundo tiempo: 20,49 *vs* 5,21 minutos y PD = 118,8%). No se hallaron diferencias en las demás variables analizadas.
Conclusión: A partir de los resultados obtenidos podemos concluir que no existen diferencias de carga interna y externa en jugadores adultos con jugadores sub-19, con excepción de velocidad máxima y zona 3 de frecuencia cardiaca en este equipo durante un partido no oficial. Por lo que, para efectos prácticos, los jugadores Sub-19 de este equipo, podrían encontrarse en condiciones para enfrentar las exigencias físicas que requiere la competencia de categoría adulta.

Palabras clave:
Deportes. Frecuencia cardiaca. Fútbol. Monitoreo fisiológico.

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Introduction

Soccer is an intermittent sport in which high intensity action and rest periods alternate[1,2]. In recent decades, the competitive aspects of soccer have evolved[3], which is why greater emphasis has been placed on the development of players' physical qualities, this factor being considered the basis for their technical and tactical training[4]. Physical load can be described as external load (EL) (e.g. total distance, sprint distance, etc.) and acute responses which occur as a result of training or a match, also called internal load (IL) (e.g. heart rate, lactate, etc.)[5], and technical teams spend considerable time monitoring the physical load their players endure[6]. Research can be found in the scientific literature which provides varied information regarding the IL and EL of players in different categories and of different ages[7,8]. The growing interest in analysing IL and EL over the 90 minutes of a match is justified by the need for players to adapt to the multifactorial physical demands of a game[9], understanding that their technical and tactical performance relies on their physical performance[10]. The identification of the IL involved in soccer reveals essential information which can help improve players' training and recovery strategies[11], and also determine the onset of fatigue[12–14].

Methods based on measuring the heart rate (HR) in training or competition have been used to assess IL[6]. Alexandre *et al.* (2012)[11] state that HR constitutes one of the physiological variables most used to quantify the IL of soccer players. It allows us to determine when players' performance drops and when fatigue sets in[14]. Mean exercise intensity has been reported to range from 80 to 90% of maximum heart rate (HRmax)[11].

With regard to EL, information can be found on the movements made by soccer players, where it has been established that the distance covered (DT), regardless of the players' level of perfection, ranges from 9 to 14 km per game[2,15]. Another measurement which indicates players' athletic performance is variation in the speed of movements during a game[16]. It has been reported that during matches soccer players run 22-24% of the time at speeds over 15 km/h (high intensity threshold; corresponding to the speed above mean speed at the second ventilatory threshold in professional soccer players), 8-9% at more than 20 km/h (very high intensity threshold; corresponding to the speed above mean maximal aerobic speed in professional soccer players), and 2-3% at over 25 km/h (sprint threshold; corresponding to the closing speed at maximum sprint speed when professional soccer players run)[17].

This information makes it possible to quantify players' work-rate profiles, helping coaches identify their players' performance[18]. Studies show that speed or sprint actions are carried out frequently during soccer matches [2,19]. The ability to sprint repeatedly throughout a game allows us to distinguish different performance levels in players[20]. This indicator can be analysed by determining the total number of sprints, the distance covered or the duration of high-speed activity registered by the players[21]. In this way, it is possible to understand empirically that high-speed efforts in a soccer match are not stable properties and that they depend on factors such as the physical condition of the player, environmental conditions and the tactical functions of the players[16,22].

The use of technology by means of satellite location systems (GPS) means researchers can evaluate EL and IL in intermittent high-intensity team sports, monitoring, assessing and controlling athletic performance[23,24]. The development of specific recording instruments for team sports has provided an essential tool to learn more about the activity patterns of these disciplines and for the quantification of training loads[25]. This technology has also been applied to detect the onset of fatigue in matches and identify the most intense periods of play and different activity profiles by position, level of competition and sport[12,26]. The importance of quantifying the exertion load in soccer contributes to a better understanding of the specific physical and physiological demands of the sport and opens the way to optimising athletic performance in the game[21].

To our knowledge, IL and EL match data are not available between the adult and under-19 categories, so having them could help coaching teams make decisions from a conditional perspective when it comes to identifying whether youth players are prepared to face the adult category and even to see if they are ready to join it. The objective of this research was to assess the IL and EL of players in a professional Chilean first division team in real game conditions during an unofficial match and determine the differences between the adult and under-19 categories of the same club using GPS.

Materials and method

Design

This research took a quantitative, non-experimental, cross-sectional and descriptive approach.

Description of the sample

The sample consisted of 12 soccer players, 7 adult professionals (25.57 ± 5.06 years old) and five under-19 players, (18.6 ± 0.54 years old) belonging to a professional soccer club (Table 1), who competed in the Chilean national championship in the first division adult and youth categories. All the participants were informed of the study's objectives and voluntary nature through informed consent according to the Declaration of Helsinki (2013)[27]. These documents were read and signed by each of the participants. Authorisation was also requested from the bodies responsible for the club.

Procedures

The assessment of IL in this study was conducted using heart rate parameters, while EL was assessed using variables of total distance covered, speed and number of sprints. The data used for the study were from players who took part throughout the match. Warm-up data were not included in the match load. The match was played on a natural

Table 1. Characteristics of the sample.

Category	n	Age M ±SD	Height (m) M ±SD	BM (kg) M ±SD	BMI M ±SD
Adults	7	25.57 ±5.06	1.74 ±0.06	71 ±4.97	23.47 ±0.63
Under-19	5	18.6 ±0.54	1.77 ±0.02	72.38 ±2.61	22.82 ±1.15

M: mean; SD: standard deviation; n: sample number; BM, body mass; BMI: body mass index.

grass pitch using studded boots. The match took place at 10 a.m. and respected official match times: 2 halves of 45 minutes with a halftime break of 15 minutes.

Instruments and materials

The SPI elite GPS system, designed and developed by the Australian company GPSports Systems[28]. This device is capable of recording athletes' movements, speeds and heart rate. The SPI elite has the following characteristics: GPS (sampling frequency: 1 Hz), heart rate monitor, triaxial accelerometer, dimensions of 91mm x 45mm x 21mm and a weight of 75g. When the player's performance is captured by the SPI elite, the data is downloaded to a computer to be analysed and handled using the TEAM AMS software designed by the company GPSports Systems, a programme which generates reports via spreadsheets.

The assessment of the players' EL was determined on the basis of proposals found in the scientific literature in order to make possible comparisons. The distance covered was quantified in the five speed intensities established by Di Salvo *et al.* (2007)[29]: D_{1-11} (0 to 11 km/h standing, walking or jogging), D_{11-14} (11.1 to 14 km/h low-speed running), D_{14-19} (14.1 to 19 km/h moderate-speed running), D_{19-23} (19.1 to 23 km/h high-speed running) and D_{23} (>23 km/h sprinting). The total distance covered (TD) and the maximum speed reached during the match (MS) were also calculated.

IL was measured using the heart rate recorded. It was classified into the six activity zones established by Cunniffe *et al.* (2009) based on the maximum heart rate reached during the match (HRmax) (30): Zone 1 (HR1) (0 to 60% HRmax), zone 2 (HR2) (60 to 70% HRmax), zone 3 (HR3) (70 to 80% HRmax), zone 4 (HR4) (80 to 90% HRmax), zone 5 (HR5) (90 to 95% HRmax) and zone 6 (HR6) (95 to 100% HRmax). The mean heart rate during the match (MHR) was also calculated.

Statistical analysis

The descriptive statistics of the data were presented as mean and standard deviation. The Shapiro-Wilk normality test was used to discover the data distribution, and Levene's test was used to assess homoscedasticity. A non-normal distribution of variables was verified, and their homoscedasticity was accepted. The nonparametric Mann–Whitney U test for independent samples was applied to determine whether there were differences between groups. Effect size was calculated via the percentage difference (PD) between categories[31]. All the statistics were processed with SPSS v.25 software with an alpha of $p<0.05$.

Results

Tables 2 and 3 show the description of IL and EL in the first half (T1), second half (T2) and total match (TM) split into the adult and U19 categories. It can be observed that differences ($p<0.05$) were only found in EL in the MS variable in T1 and TM, the U19 players reaching the highest values (T1-MS: 32.34 vs 27.77 km/h and PD = 15.3%; TM-MS: 32.6 vs 28.14 km/h and PD = 14.7%). Meanwhile, differences were only found in IL in the HR3 variable in T1 and T2, with the U19 players spending more time in this zone (T1-HR3: 6.1 vs 1.73 minutes and PD = 111.6%; T2-HR3: 20.49 vs 5.21 minutes and PD = 118.8%). No differences were found in the other variables analysed.

Discussion

GPS is a useful tool to control and understand the specific physical demands of this sport and thus contribute to the design and planning of training to optimise players' performance in competitions (25). This study aimed to assess and discover differences in internal load (IL) and external load (EL) between adult and youth soccer players in a friendly match using portable GPS devices. Its main findings were differences in EL in the MS variable in T1 and TM, the U19 players reaching the highest values. Differences were also found in IL in the HR3 variable in T1 and T2, with the U19 players spending more time in this zone.

That no differences were found in the other IL and EL variables can be explained by the physical condition of each category and the training loads (IL and EL during the week) to which they may have been subjected during the season. Rabbani *et al.* (2021)[32] compared the adult category (age: 28.3 ±2.0 years old) with the U19 category (age: 18.0 ±0.4 years) of a first division team in Iran in tests of acceleration (time 0 to 10 metres), speed (time 0 to 30 metres), change of direction (505 test) and intermittent fitness (30-15 IFT), and IL was assessed indirectly through rate of perceived exertion (RPE), finding that adult players performed better in acceleration tests (Effect size [ES]= 0.96), speed (ES=0.81) and change of direction (ES=0.24), but U19 players performed better in terms of intermittent fitness (ES=0.34). In turn, the U19 players had higher RPEs than the adult category, except during matches, where only trivial differences were found. Another study found similar results regarding training load, where the EL of an adult team (age: 25.9 ±5.2 years old) was compared with that of the U19 category (age: 18.7 ±1.3 years old) of a French second division team over a season, and it was found that the loads were similar and that, for some variables, the values registered in the U19 category were actually higher[33]. Assuming that training loads cannot be the same in different clubs, something similar could occur in our study and explain why there are no significant differences in most of the EL and IL variables.

Table 2. Descriptive and inferential statistics of the first and second halves.

Variables	1st Half						2nd Half					
	Adult		U19		Inter-groups		Adult		U19		Inter-groups	
	M	±SD	M	±SD	p	PD	M	±SD	M	±SD	p	PD
External load												
TD (m)	5480	208	5275	409	0.37	3.8	4866	738	4990	464	0.68	2.5
MS (km/h)	**27.7**	**2.3**	**32.3**	**2.5**	**0.02***	**15.3**	26.2	3.1	27.9	1.5	0.28	6.3
D1-11 (m)	3399	146	3322	190	0.68	2.3	3104	383	3260	179	0.46	4.9
D11-14 (m)	943	161	788	18	0.22	17.9	807	164	698	167	0.16	14.5
D14-19 (m)	792	167	769	140	0.46	2.9	707	143	685	200	0.37	3.2
D19-23 (m)	241	61	259	75	0.93	7.2	181	73	254	95	0.37	33.3
D23 (m)	104	69	134	61	0.46	25.2	67	58	91	50	0.37	30.4
NS (frequency)	6.4	2.7	7.8	3	0.41	19.7	5	4.1	7	2.9	0.36	33.3
Internal load												
MHR (ppm)	168	51	180	13	0.8	6.9	154	44	170	12	0.46	9.9
HRmax (ppm)	190	45	207	11	0.74	8.6	185	53	202	11	0.93	8.8
HR1 (min)	3.1	8	0.1	0.2	0.69	187.5	3.9	9.7	0.2	0.3	0.6	180.5
HR2 (min)	3.4	8.3	0.5	0.6	0.89	148.7	0.9	0.9	2.5	2.5	0.22	94.1
HR3 (min)	**1.73**	**1.9**	**6.1**	**3.4**	**0.02***	**111.6**	**5.2**	**5.3**	**20.4**	**22.2**	**0.04***	**118.8**
HR4 (min)	12.6	9.2	19.8	2.1	0.08	44.4	14.2	8.1	18.7	4.4	0.46	27.6
HR5 (min)	15.5	7.9	14.2	3.9	0.22	8.8	14.9	12.3	10.2	3.5	0.46	37.7
HR6 (min)	8.3	6.3	4.1	1.1	0.29	67.7	5.72	4.8	3.4	2.9	0.46	50.9

*differences <0.05; M: mean; SD: standard deviation; PD: percentage difference; TD: total distance; MS: maximum speed; D1-11 total distance 1-11 km/h; D11-14 total distance 11-14 km/h; D14-19 total distance 14-19 km/h; D19-23 total distance 19-23 km/h; D23 total distance over 23 km/h; NS: number of sprints; MHR: mean heart rate; HRmax: maximum heart rate; HR1 time in heart rate zone 1; HR2 time in heart rate zone 2; HR3 time in heart rate zone 3; HR4 time in heart rate zone 4; HR5 time in heart rate zone 5; HR6 time in heart rate zone 6.

The MS values obtained by the U19 category were similar in the study by Hespanhol *et al.* (2021)[34], who related body composition and states of biological maturation with maximum speed reached during a soccer match, finding that more biologically developed players, post peak height velocity (PHV), had higher MS (32.22 ±1.79 km/h) than players pre-PHV (21.91±2.56 km/h) and at PHV (29.77 ±2.16 km/h), which may be consistent with the age range of our sample. In turn, Zúñiga-Morales *et al.* (2021)[35] reported mean maximum speed values of 28.4 ±2.5 to 29 ±2.3 km/h in professional players belonging to a Costa Rican first division club during 5 pre-season friendly matches, reporting values slightly higher than those obtained by the professional squad, although it should be taken into account that, in this case, the players were only assessed once and against a youth team. However, the values obtained by the professional players in our study are similar to those found by Mallo *et al.* (2015)[36], who reported a mean maximum running speed of 28.3 ± 2.5 km/h in professional soccer players in Spain during 11 pre-season friendly matches. There is a decrease in DT of 5% during the second half reported by Krustup, *et al.* (2001)[37] and of 3% according to Mohr *et al.* (2003)[38], similar to those found in both categories.

The HR zones proposed by Cunniffe *et al.* (2009)[30] show that the U19 players spent more time in HR3 (6.1 vs 1.73 and 20.49 vs 5.21), but no differences were reflected in the distances in any specific speed range, so these differences could be attributed to the different positions in which the players play[39], performance fatigability or the perceived fatigability with which they arrived at the match[40,41]. In Vargas *et al.* (2014)[42], MHR values of 165.85±14.88 ppm and HRmax of 189.25 ±5.96 ppm were recorded during pre-season matches, which are similar to those obtained by the professional players but lower than those recorded by the U19 players in our study. The MHR values are 88.4% and 86.9% of HRmax, which are higher than those recorded by Stølen *et al.* (2005)[10] in elite players. This would imply that age and competitive level may be a differentiating factor in physical performance[43].

Regarding the results obtained, we recognise limitations in our study, mainly referring to the sample size, which only includes two soccer teams, which are different categories in the same club, so it is not possible to generalise the values reported in this study to other teams of the same competitive level, It should also be noted that the data were collected during a single unofficial match, and different responses in the variables studied might be expected in an official match, where the values and differences between groups might increase due to the intrinsic motivation of competition and tactical behaviour[39,44]. Playing position should also be considered in the analysis, because the

Table 3. Descriptive and inferential statistics of the total match.

Variables	Adult		Under-19		Inter-groups	
	M	±SD	M	±SD	p	PD
External load						
TD (m)	10347	671.9	10265	813	0.465	0.8
MS (km/h)	**28.14**	**2.27**	**32.6**	**2.41**	**0.018***	**14.7**
D1-11 (m)	6502	502.9	6582	345.5	0.935	1.2
D11-14 (m)	1751	196.6	1488	320.1	0.167	16.3
D14-19 (m)	1499	171.7	1455	340.6	0.372	3.0
D19-23 (m)	422.7	97.83	514	154.3	0.372	19.5
D23 (m)	171.1	109.9	225.4	86.01	0.167	27.4
NS (frequency)	11.43	5.83	14.8	5.22	0.188	25.7
Internal load						
MHR (ppm)	161.1	46.89	175.6	12.94	0.685	8.6
HRmax (ppm)	191.7	45.94	207.4	11.5	0.745	7.9
HR1 (min)	7.11	12.1	0.33	0.46	0.603	182.3
HR2 (min)	4.37	7.97	3.12	3.19	0.935	33.4
HR3 (min)	6.94	7.05	14.6	8.11	0.123	71.1
HR4 (min)	26.81	16.41	38.59	5.71	0.167	36.0
HR5 (min)	30.53	9.26	24.53	6.67	0.167	21.8
HR6 (min)	14.04	10.49	7.64	2.98	0.291	59.0

*differences <0.05; M: mean; SD: standard deviation; PD: percentage difference; TD: total distance; MS: maximum speed; D1-11 total distance 1-11 km/h; D11-14 total distance 11-14 km/h; D14-19 total distance 14-19 km/h; D19-23 total distance 19-23 km/h; D23 total distance over 23 km/h; NS: number of sprints; MHR: mean heart rate; HRmax: maximum heart rate; HR1 time in heart rate zone 1; HR2 time in heart rate zone 2; HR3 time in heart rate zone 3; HR4 time in heart rate zone 4; HR5 time in heart rate zone 5; HR6 time in heart rate zone 6.

physiological response shown through IL and EL is related to the characteristics and specific requirements of the position[39,43]. The results and analysis of this study do not permit any explanation of the performance of a team because technical and tactical factors, and the internal logic of the game are not taken into consideration, it only being possible to provide a vision of the conditional and individual aspects of the players[45].

Considering the limitations of the study, it has been possible to compare the physical profiles of soccer players during an unofficial match and to see the degree to which the variables studied manifested themselves during the game for different competitive categories. The data presented in this study, which focuses on a sample of Chilean athletes, aims to serve as an aid for coaching teams by allowing them to make plans based on the physical demands of the game in the different categories and to fill the research gap faced by Chilean soccer in this field, contributing to the collection of data which could benefit the sports performance of teams and making the information recorded available to portray the reality of soccer players in the national sporting landscape, opening the way to future research to favour the different participants in this sport.

Conclusion

From the results obtained, we can conclude that there are no differences in internal and external load between adult and under-19 players, with the exception of MS and HR3, during an unofficial match. Therefore, for practical purposes, the U19 players in this team could be in a position to meet the physical demands that competition in the adult category requires. Finally, due to the low number of participants and data collection over time (longitudinal), it is necessary to continue research to corroborate and confirm these results in other teams.

Contributions of the authors

J.P-C: Design, analysis and composition of the manuscript; S.E-M: Design, data collection and composition of the manuscript; R. V-V: Composition of the manuscript; E.A-M: Analysis, data collection and composition of the manuscript; B.M: Analysis and composition of the manuscript; P.M-M: Design, analysis and composition of the manuscript.

Conflict of interest

The authors declare that they are not subject to any type of conflict of interest.

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Original article

Determining factors with regard to physical functional impairment in revascularized patients with acute coronary syndrome

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Summary

Introduction: Functional physical capacity is indirectly associated with mortality, and may be compromised after a cardiovascular event, hence the importance of considering its prognostic factors during treatment in heart disease patients.
Aim: To identify the prognostic factors of functional physical limitation in patients with myocardial revascularization for acute coronary syndrome.
Material and method: A retrospective analysis was carried out of 29 medical records taken from patients submitted to a stress test (Bruce, modified Bruce) after myocardial revascularization during the months of January to December 2019. For the statistical analysis, a univariate and multivariate logistic regression (Odds Ratio-OR) was performed, as well as a simple linear regression analysis between the variables of interest.
Results: the analyzed patients had a mean age of 60 ± 9,2 years, and 76% were men. The presence of systemic arterial hypertension (SAH), lower values of Maximum Heart Rate (HR) (ß = 0,112; CI: 0,074, 0,149; p <0.001), high values of Systolic Arterial Pressure (SBP) (ß = - 0,083; CI 95%: -0,152, -0,014; p <0.020), and a greater number of risk factors (ß = - 1,580; CI 95%: -2,456-0,868; p <0.001), are considered predictors of functional limitation (<7 METs).
Conclusion: The presence of SAH, a greater number of risk factors, as well as high maximum SBP levels and lower maximum HR values reached during the stress test, were shown to be prognostic factors of functional limitation in subjects revascularized for ACS.

Key words:
Rehabilitation. Exercise test. Myocardial ischemia.

Factores determinantes de la limitación física funcional en pacientes revascularizados por síndrome coronario agudo

Resumen

Introducción: La capacidad física funcional se asocia de manera indirecta con la mortalidad, y frecuentemente se ve comprometida después de un evento cardiovascular, de ahí la importancia de considerar sus factores pronósticos durante el tratamiento en los pacientes cardiópatas.
Objetivo: Identificar los factores pronósticos de la limitación física funcional en pacientes revascularizados por Síndrome Coronario Agudo (SCA).
Material y método: Se realizó un análisis retrospectivo de 29 historias clínicas tomadas de pacientes sometidos a una prueba de esfuerzo (Protocolo Bruce o Bruce modificado) posterior a una revascularización miocárdica durante los meses de enero a diciembre del 2019. Para el análisis estadístico se realizó una regresión logística univariada y multivariada (*odds ratio*-OR), así como un análisis de regresión linear simple entre las variables de interés.
Resultados: los pacientes analizados tenían una media de edad de 60 ± 9,2 años, y el 76% fueron hombres. La presencia de hipertensión arterial sistémica (HAS), menores valores de Frecuencia Cardíaca (FC) máxima (ß = 0,112; CI: 0,074, 0,149; p <0,001), altos valores de Presión Arterial Sistólica (PAS) (ß = - 0,083; CI 95%: -0,152, -0,014; p <0,020), y un mayor número de factores de riesgo (ß = - 1,580; CI 95%: -2,456-0,868; p <0,001), son considerados predictores de limitación física funcional (<7 METs).
Conclusión: La presencia de HAS, un mayor número de factores de riesgo, así como altos niveles de PAS máxima y menores valores de FC máxima alcanzadas durante la prueba de esfuerzo, mostraron ser factores pronósticos de la limitación funcional en sujetos revascularizados por SCA.

Palabras clave:
Rehabilitación. Prueba de esfuerzo. Isquemia miocárdica.

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Introduction

The effort test in revascularized patients with coronary artery disease has primarily been used for diagnostic purposes in order to detect residual ischemia, arrhythmias, symptoms and dynamic physiological responses before starting a cardiac rehabilitation programme. Approximately 30% of these programmes conduct effort tests, despite the fact that these tests are considered to be the gold standard for starting rehabilitation. The increase in longevity and in the multimorbidity conditions of the revascularized population, makes its use appear more relevant in order to guide the prescription and progression of pharmacological and physical exercise treatments that are commonly provided to these patients [1,2].

The information commonly extracted during effort tests on this type of patient includes: maximum heart rate and maximum work load determined by fatigue, angina or electrocardiographic evidence of ischemia. The above makes it possible to establish safe training intensities in order to increase the functional physical capacity[3,4,1]. This capacity or physical aptitude is commonly reported using metabolic equivalents (METs) and it has been shown to be a prognostic indicator for event-free survival, all-cause mortality and cardiovascular events[5,6]. Its increase is accompanied by positive influences on the vascular, cardiac, haematological, immunological and nervous systems, it is also considered to be a stronger predictor of mortality when compared to nicotinism, SHBP, high cholesterol, diabetes mellitus and other predictors obtained in an effort test such as segment depression[7].

In view of all the foregoing, the increase in functional physical capacity must be considered to be a fundamental treatment goal for revascularized patients[7]. Furthermore, by recognising factors that exert an influence on functional physical capacity, this could help to improve the coronary disease control strategies following a surgical intervention. Therefore, this study aims to identify the prognostic factors of functional impairment measured through an ergometric test in revascularized patients with acute coronary syndrome.

Material and method

A cross-sectional, descriptive retrospective study was conducted, based on the information derived from the twenty-nine medical histories of patients subjected to an ergometric test after having undergone, for the first time, a revascularization process for acute coronary syndrome (ACS) in the Instituto del Corazón de Bucaramanga (ICB) (Bucaramange Heart Institute) between the months of January and December 2019. The following information was obtained: age, sex, height, weight, ACS type, revascularization type, participation in cardiac rehabilitation programme, number of sessions prescribed, number of sessions completed, cardiovascular risk factors and re-hospitalizations subsequent to revascularization.

Given that the effort tests selected had a diagnostic purpose, the patients suspended the pharmacological treatment to perform them. The only tests selected were those with no electrocardiographic changes compatible with ischemia or rhythm disorders, and in which the reason for the suspension of the tests was fatigue. The variables analysed were: protocol type (Standard Bruce and modified Bruce), baseline HR, maximum HR achieved during the effort test, baseline SAP, maximum SAP achieved during the effort test,baseline SAP, maximum SAP achieved during the effort test, Diastolic Arterial Pressure (DAP), maximum DAP achieved during the effort test, maximum oxygen consumption ($VO_{2máx}$) obtained by indirect measurements, METs, and presence of functional impairment "<7 METs of tolerance to exercise"[8,9].

Statistical analysis

The information obtained was digitised in Excel and the results were analysed through Stata 12.0. The continuous variables were analysed as measures of central tendency and dispersion, the categorical variables through absolute and relative frequencies. In order to estimate the influence of the different factors associated with the functional impairment of the target population of the study, a univariate and multivariate logistic regression was performed (*Odds Ratio*-OR). Additionally, Pearson's test was used to conduct a correlation analysis between tolerance to efforts in METs and the continuous variables of interest. Finally, a simple linear regression analysis was made with those variables showing significant results in the correlation. Associations with $p<0.05$ were considered to be statistically significant.

Ethical considerations

The authors declare that the procedures were conducted in accordance with the ethical standards of the committee responsible for human experimentation and in accordance with the World Medical Association and the Declaration of Helsinki. The study observed the ethical principles of confidentiality, goodwill, non-dysfunction, autonomy and justice. Finally, this investigation was approved by the ethics committee of the Universidad Santo Tomás-Seccional Bucaramanga. (Ethical concept #01402020-1012032020).

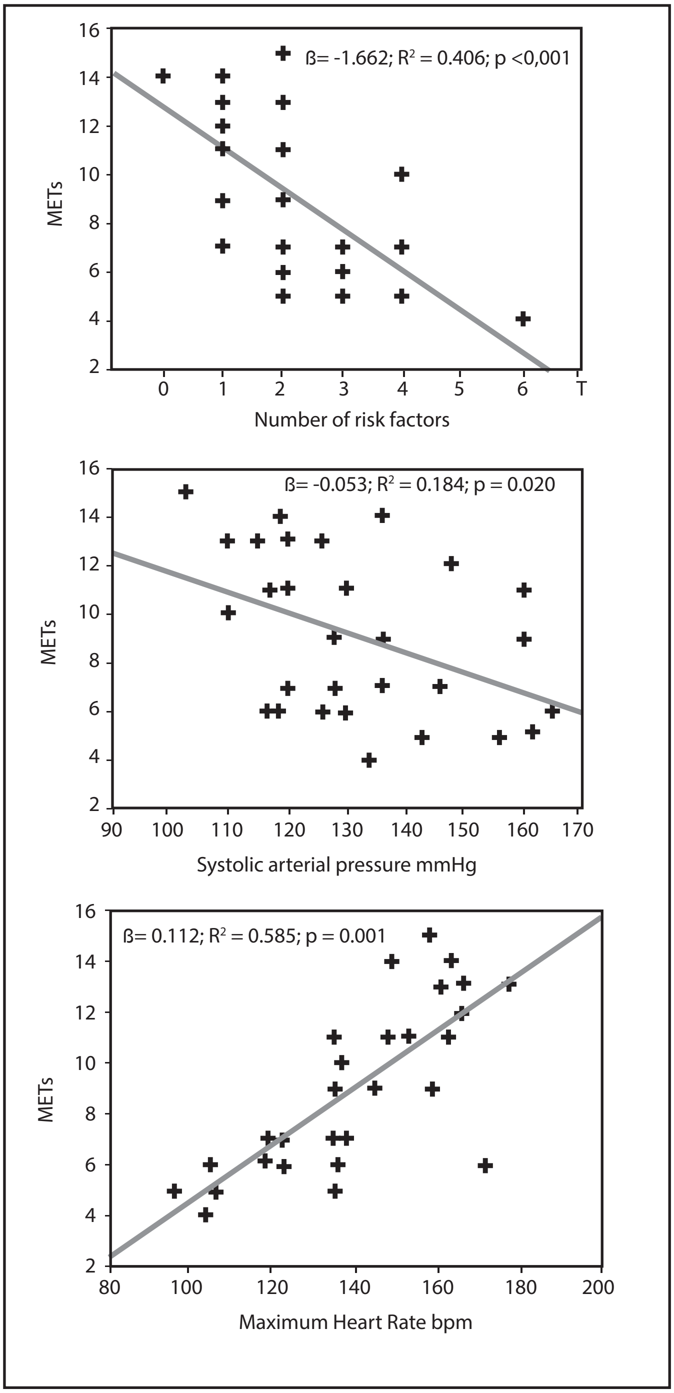
Results

Of the population analysed: the mean age was 60 ± 9.2 years, 76% were men, the most prevalent risk factor was the SHBP present, 83% underwent percutaneous coronary intervention, 86% performed the standard Bruce test and 31% exhibited functional impairment (Table 1).

In the univariate and multivariate analysis, the functional impairment was associated with the presence of hypertension. Hypertension sufferers are 16 times more likely to show functional impairment in comparison with those for whom this diagnosis was not reported (Table 2).

Table 3 shows a direct relationship between tolerance to physical effort and MHR and an indirect relationship between this same variable and the number of risk factors and SAP. According to the linear

Figure 1. Linear regression analysis between functional physical capacity, number of cardiovascular risk factors, SAP and MHR.



regression analysis, an increased MHR value could increase the METs by 0.11 (ß = 0.112; CI: 0.074, 0.149; $p < 0.001$); additionally, for each mmHg increase of SAP, the METs decreased 0.08 (ß = - 0.083; CI 95%: -0.152, -0.014; $p < 0.020$), and for each risk factor unit increase the METs decreased 1.5 (ß = - 1.580; CI 95%: -2.456-0.868; $p < 0.001$) (Figure 1).

Table 1. General characteristics of the population.

Variable		n=29	%
Sex (Male)		22	76
Risk factors			
	Obesity	13	44
	AHT	14	48
	Diabetes	3	10
	Dyslipidemia	10	34
	Nicotinism	3	10
	Ex-nicotinism	12	41
	Family history	1	3
Type of ACS	NSTE-ACS	13	45
	STE-ACS	6	21
	Unstable angina	10	34
Type of percutaneous		24	83
revascularization	Bypass	5	17
Protocol	Bruce Standard	25	86
	Bruce Modified	4	14
Participation in CR		25	86
Functional impairment (<7 METs)		9	31
Rehospitalized		11	38
Variables		**Mean**	**±SD**
	Age (years)	60	9.2
	Height (cm)	166	8.3
	Weight (Kg)	73	10
	BMI (Kg/m²)	26	3
Rehabilitation	Prescribed	21	20
sessions	Completed	16	12
Heart rate	Baseline	67	7,3
	Maximum	141	23
	%Maximum HR	86	12
Blood pressure	SAP	132	17
	DAP	74	10
	Maximum SAP	161	19
	Maximum DAP	84	12
Physical capacity	METs	9	3
	VO_{2max}	32	12

AHT: Arterial hypertension: HR: Heart rate: NSTE-ACS: Non-ST elevation-acute coronary syndrome: STE-ACS: ST elevation acute coronary syndrome: CR: Cardiac rehabilitation; BMI: Body mass index; SAP Systolic arterial pressure: DAP: Diastolic arterial pressure; $VO_{2máx}$: Maximum oxygen consumption.

Discussion

The presence of SHBP, a greater number of risk factors, high levels of maximum SAP and lower maximum HR values achieved during the effort test were shown to be prognostic factors of functional impairment in subjects revascularized for ACS.

The evidence found shows an indirect relationship between functional capacity and arterial pressure levels in hypertensive and normotensive patients[10-14]. Although Tadic M, Ivanovic B. 2014 reported that the mechanisms for the relationship are not entirely clear, they do

Table 2. Factors associated with functional impairment of revascularized patients for ACS.

Variable	OR (95%IC)	p Value	AOR (95% CI)	p Value
Obesity	3.7 (0.704; 19.58)	0.122		
AHT	18 (1.893; 184.0)	0.012	16 (1.010-275.0)	0.049
DM	1.12 (0.088; 14.27)	0.132		
Dyslipidemia	1.86 (0.367; 9.487)	0.452		
Nicotinism	1.12 (0.088; 14.27)	0.928		
Ex-nicotinism	0.10 (0.010; 0.977)	0.048	0.06 (0.003-1.292)	0.704
Participation in CR	0.38 (0.045; 3.323)	0.338		
Rehospitalisation	0.34 (0.057; 2.115)	0.252		

OR: Odds Ratio; AOR: Adjusted Odds Ratio by sex, obesity and diabetes *mellitus*.

Table 3. Correlation between the number of cardiac rehabilitation sessions, effort tolerance level and variables of interest.

Variable	METs r	p
Age -	- 0.24	0.198
BMI	- 0.36	0.050
Number of risk factors	- 0.63	0.002
BHR	0.03	0.873
Maximum HR	0.76	<0.001
SAP	- 0.42	0.020
DAP	- 0.01	0.878
Maximum SAP	- 0.32	0.089
Maximum DAP	- 0.34	0.237

NCRS: number of cardiac rehab sessions; BMI: Body Mass Index: BHR: Baseline Heart rate: SAP: Systolic arterial pressure: DAP: Diastolic arterial pressure; * p <0,05 Spearman test.

point to some possible reasons such as the presence of endothelial dysfunction, mitochondrial and oxidative stress, which could lead to important alterations in the oxygen delivery and uptake rates in the tissues, thereby affecting functional capacity[15-18]. There are other factors that could reduce the level of tolerance to effort in this population, such as an increase in the left ventricle filling pressure, which contributes to the dysfunction and dilatation of the left auricle, thereby deteriorating the diastolic phase of the left ventricle, reducing the cardiac output during physical effort[16,19,20].

The prognostic value shown by the maximum HR could be justified, taking into account the fact that this determines approximately 30% of the maximum cardiac output, thereby influencing the kinetics of oxygen consumption, a variable that defines the functional physical capacity[21]. Moreover, it is known that in apparently healthy subjects, VO_2 increases 7.7 times during maximum intensity exercise. This is achieved thanks to an increase of: 2.5 times the HR, 2.5 times the arteriovenous oxygen difference and 1.4 times the systolic volume, the above being one of the reasons why the HR is considered to be one of the factors that most helps to maintain the functional physical capacity[22,23].

The increase in the maximum HR is primarily conditioned by the expression and functional activity of the adrenergic receptors and by the efficiency of the excitation-contraction coupling. Although these factors are commonly attenuated by ageing and by the extent of the lesion caused by coronary disease, this progressive reduction or alteration of the response of the heart to adrenergic stimulation, does not appear to be so significant in those in better physical condition[21,24-26].

There are other factors that are characteristic of coronary disease and some that are considered to be adverse effects of the anaesthesia or revascualrization surgery, such as the dilatation of the left ventricle and damage to the sinoatrial node that could affect chronotropic performance and the cardiovascular autonomic functions[27,28]. Although the maximum HR is fundamental for the adaptation of the cardiac output to metabolic needs, its role as a biomarker or possible modifiable independent risk factor, as well as its clinical or therapeutic objective in revascularized patients is not clear. For this reason, some studies emphasise the importance of analysing its behaviour, which could strongly predict the evolution of patients of this type[27,21].

The physical functional capacity is considered to be a prognostic factor of the burden of disease for patients with coronary disease. Specifically, the high levels of this capacity are associated with the mitigation of the risk factors, new coronary events, all-cause mortality and cardiovascular events[4,5,29-32]. The above is in keeping with what has been shown in this study, in which the number of cardiovascular risk factors, and the presence of SHBP in particular, were considered to be predictors of functional limitation in subjects subjected to an effort test after having undergone, for the first time, a revascularization process for acute coronary syndrome (ACS). The literature available suggests including cardiorespiratory capacity as part of the risk stratification processes, in patients with cardiovascular disease, which would substantially improve the accuracy of this process[7]; this is taking into account the fact that this variable has been shown to be a stronger predictor when compared to traditional risk factors or those obtained in the effort test such as the depression of the ST segment, the haemodynamic symptoms and responses[7,33,34].

The limitations found include: the nature of the study, that does not make it possible to control the result of the evaluations, thereby depending on the record reported in the medical histories; the size of the sample that may have been insufficient to detect any other significant associations; the obtaining of the physical capacity by indirect methods, which could be lacking in accuracy, considering that predictive models are more susceptible to confusion factors. Furthermore, it is possible that the results analysed are influenced by the ceiling effect, present when the HR is used as a determining factor of the effort test termination, and by the learning effect, when the patient does not have the possibility to become familiar with the use of the treadmill before starting the test[35].

Conclusions

Our work reinforces the importance of adequate handling of co-morbidities and SHBP in particular, in order to improve the functional capacity of these individuals. The increase in the maximum HR and the attenuation of the SAP are determining factors in the increased tolerance to physical effort in revascularized patients.

The effort tests analysed had a diagnostic objective and, for this reason, it is suggested that they also be used as a patient risk stratification tool based not only on the use of the METs achieved but also on the performance of haemodynamic variables that are simple and relatively easy to obtain such as the maximum HR and the SAP, which were shown to be related to tolerance to physical exercise. They could also show prognostic values for other important conditions to be taken into account during the post-surgery period such as event-free survival levels, all-cause mortality and cardiovascular events in revascularized patients for ACS.

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Conflict of interest

The authors do not declare a conflict of interest.

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Blood flow restriction training on hypertesive subjects: a systematic review

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Summary

Introduction: Systemic arterial hypertension has been growing worldwide, causing thousands of deaths and large expenses in this condition treatment. Currently, resistance training (RT) is widely prescribed as a non-pharmacological option for blood pressure control, but there are some individuals with intolerance to high load of RT. Hence, blood flow restriction is a method created to stimulate high level of physiological adaptations with low resistive load. However, there are uncertainties about safety and efficacy of this method.
Objective: The present study aimed to investigate the safety and efficacy of blood flow restriction training in hypertensive individuals.
Material and method: The research was carried out through a systematic review within the criteria established by the PRISMA statement. Only studies about blood flow restriction in subjects with arterial hypertension were selected in the following databases: MEDLINE/PUBMED, Web of Science, SCOPUS and SPORTDiscus.
Results: Five studies (4 acute and 1 chronic effects) met the requirements for the present review, with 77 hypertensive individuals. Only one study presented levels of blood pressure above to the recommended for hypertensive subjects.
Conclusion: Even though the number of studies is still insufficient to conclude about the efficacy, the results allow concluding that resistance training with blood flow restriction is a safe alternative of exercise method to hypertensive subjects, especially for those with intolerance to high training loads.

Key words:
Blood flow restriction training. Blood pressure. Heart disease. Hemodynamics.

Entrenamiento de restricción del flujo de sangre en sujetos hipertensivos: revisión sistemática

Resumen

Introducción: La hipertensión arterial sistémica ha ido creciendo a nivel mundial, provocando miles de muertes y grandes gastos en el tratamiento de esta afección. Actualmente, el entrenamiento de fuerza se prescribe ampliamente como una opción no farmacológica para el control de la presión arterial, pero hay algunas personas con intolerancia al entrenamiento de alta intensidad. Por ello, el entrenamiento de restricción del flujo sanguíneo es un método creado para estimular los altos niveles de adaptación fisiológica con cargas de baja intensidad. Sin embargo, existen incertidumbres sobre la seguridad y eficacia de este método y no hay consenso al respecto.
Objetivo: El presente estudio tuvo como objetivo investigar la seguridad y eficacia del entrenamiento de restricción del flujo sanguíneo en individuos hipertensos.
Material y método: La investigación se realizó mediante una revisión sistemática, dentro de los criterios establecidos por la declaración PRISMA y se utilizaron las siguientes bases de datos: MEDLINE/PUBMED, Web of Science, SCOPUS y SPORTDiscus, incluyendo solo estudios con individuos con hipertensión arterial en los que se utilizó el método.
Resultados: Cinco estudios (4 efectos agudos y 1 efectos crónicos) cumplieron con los requisitos de la presente revisión, con 77 individuos hipertensos. 4 estudios evaluaron efectos agudos y 1 estudio evaluó efectos crónicos. Solo un estudio incluido presenta niveles aumentados de presión arterial por encima de los niveles recomendados en sujetos hipertensos y los otros 4 estudios demostraron la seguridad del entrenamiento de oclusión.
Conclusión: A pesar de que el número de estudios aún es insuficiente para concluir sobre su eficacia, los resultados muestran una seguridad de este método como ejercicio alternativo para sujetos hipertensos, especialmente aquellos con intolerancia al entrenamiento de cargas de alta intensidad.

Palabras clave:
Entrenamiento de restricción del flujo sanguíneo. Presión sanguínea. Cardiopatía. Hemodinámica.

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Introduction

Systemic arterial hypertension (SAH) is a chronic disease which affect approximately 1.13 billion people worldwide[1]. Its prevalence increases with aging[2] and significantly increases the risk of cardiovascular disease, which is the major cause of premature death worldwide[3]. According to American Heart Association (AHA), SAH is diagnosed when the systolic blood pressure (SBP) ≥ 140 mmHg and diastolic blood pressure (DBP) ≥ 90 mmHg, following repeated examination[4]. Additionally, AHA proposes some strategies to reduce deaths by SAH, such as lifestyle modification (e.g. physical exercise, nutrition habits) associated to pharmacological treatment[4].

Physical exercise, as a component of lifestyle changing, has been showing efficient in the treatment of arterial hypertension. Therefore, aerobic or resistance exercises are recommended as a non-pharmacological treatment for SAH[5]. Both of them can improve cardiac[6] and vascular function[7], and reduce metabolic risk[8]. According to Cornelissen *et al.*, (2013) engagement in aerobic exercise (e.g. walking, running, swimming or cycling) is recommended for patients diagnosed with SAH, at least 30 minutes/day of moderate-intensity[9], because that activity is able to reduce 8 mmHg for SBP and 5 mmHg for DBP[10]. On the other hand, International Society of Hypertension (ISH) also recommended resistance training (RT) for SAH patients, at least 2-3 days per week, for treat and control hypertension[4], and RT alone can induce a mean decrease of 8.2 mmHg for SBP and 4.1 mmHg for DBP, according to recent meta-analysis study[11]. Nevertheless, there are more scientific evidences for aerobic than RT, despite physiological benefits mediated by these exercise categories.

SAH prevalence is higher in elderly than young adults[4], and aging promotes several physiological consequences such as sarcopenia[12], dynapenia[13] and frailty[12]. Thus, RT seems to promote more powerful counter regulatory adaptations related to aging process, and could be a great non pharmacology strategy against SAH for elderly. Despite capacity of RT to reduce blood pressure, the RT load applied to promote the physiological benefits seems to be not well tolerated for elderly, sedentary young and frailty patients[14]. Then, some coaches are developing training systems and methods to reduce the training load, but preserving or improving the adaptations of conventional RT[15].

In this way, a different resistance training method known as Blood Flow Restriction (BFR) or popularly Kaatsu training, recently gained attention in scientific literature[16]. This method constitutes of the partial vascular occlusion in the muscles that will be resistance trained. According to Sumide *et al.*, (2008) vascular occlusion pressure of 50 mmHg is sufficient to improve muscle strength and endurance[17]. A recent meta-analysis conducted by Centner *et al,* (2019) conclude that low load resistance training (20-30% of 1RM) with BFR is able to induce similar muscle hypertrophy than high load resistance training (70-85% of 1RM) without BFR[18]. Consequently, BFR seems to be a great strategy to promote high anabolic stimulus with lower RT intensity for elderly, sedentary young and frailty patients[19].

There are several mechanisms involved in skeletal muscle hypertrophy induced by BFR, such as increasing in metabolic stress, cell swelling, Reactive Oxygen Species (ROS) production, hormones production and others[20]. Despite those adaptations, while some evidences show smaller increase in mean blood pressure (MAP) during RT with BFR[21,22], Domingos and Polito (2018), in a meta-analytic study, showed that RT with BFR promoted greater increase in SBP and DBP compared to RT without BFR[23]. However, those studies, including the meta-analytic review of Domingos and Polito, were not conducted in subjects with any cardiovascular condition. Thus, there is there is a lack of knowledge in the literature about the safety of this method on cardiovascular responses for SAH individuals.

In this perspective, the safety of resistance training with blood flow restriction for patients with SAH remains controversial. Therefore, the aimed of this research was investigate through a systematic review of the literature about the safety and efficacy of blood flow restriction training as a non-pharmacologic treatment for hypertensive patients.

Material and method

The procedures for this systematic review of the literature adopted followed the Guidelines of Preferred Reported Items for Systematic Reviews and Meta-Analysis (PRISMA)[24] and was registered at PROSPERO under the number 156683.

Experimental approach to the problem

The literature search was conducted in international databases, such as PubMed, Scopus, Web of Science SPORTDiscus, Science Direct, Cochrane, Physical Education Index, Scholar and CINAHL using the following search syntax: "resistance training" AND "blood flow restriction training" AND "hemodynamics" AND "hypertensive" OR "hypertensive subjects". The main purpose was to identify scientific studies related to blood flow restriction training and hypertension according to PICO strategy (patient, intervention, comparison and outcome) Patients: Hypertensive subjects; Intervention: BFR Training; Comparison: Compared to without BFR training; Outcome: Changes on blood pressure. The selection and inclusion of articles were made by 2 independent authors (TWSP and CMB)

The papers should would meet the following inclusion criteria: (a) Original articles investigating acute or chronic effects of blood flow restriction training in blood pressure; (b) Studies investigating the acute or chronic effect of blood flow restriction training in cardiac disease patients; (c) Male and/or female hypertensive subjects; (d) Studies that descript the resistance training (Frequency and duration); (e) Studies that descript the blood flow restriction (duration, pressure of occlusion and cuff type); (f) Studies published in English. To met the inclusion criteria, the included studies need to describe how subjects was diagnosed with hypertension.

Outcomes

The researchers (TWSP, CMB) evaluated independently the full-text of selected paper and conduct data extraction, such as (a) number of subjects per group, (b) duration of intervention, (c) study design, (d) intensity of exercise, (e) intensity of occlusion and (f) weekly frequency was extracted. Later, the researchers crosschecked the data to confirm their accuracy.

Risk of bias

Two expert researchers (TWSP, CMB) in exercise evaluated the methodological quality of the selected papers by TESTEX, according to Smart *et al*.,[25]. To reduce the chance of bias, only studies above 8-14 points in the TESTEX scale are included in the current systematic review.

Results

Search results

The search returned 185 articles. After the exclusion of duplicate records, and exclusion by title and abstract, there were 11 articles for reading in full. In the end, 5 studies met the eligibility criteria and were includes in this review. All steps of search results are described in Figure 1. Study quality of included studies was assessed through TESTEX scale and is described in Table 1. All studies were pointed with a quality between 8 and 14 points and the mean quality of the included studies was 10,8 points. 3 studies include range between 8-10 points (Table 1) and 2 studies range between 11-14 points (Table 1). The points between 8-10 indicates that they had moderate quality and those ranged between 11-14 indicates high quality.

Studies Characteristics

The 5 studies included in this systematic review have a total of 77 hypertension individuals and the characteristics is described Table 2. All studies reported the age as mean ± standard deviation. The age of 77 participants was between 44.9 ± 5.1 and 67.0 ± 7.0 years old. According to Body Mass Index (BMI), the participants included in all studies was classified as overweight (25.0-29.9) or obesity class 1 (30.0-34.9). All studies used subjects clinically diagnosed with hypertension. 4 studies used sedentary individuals or that were not involved in any resistance exercise program for the previous six months[26–29] and only one study used individuals with at least one year of recreational resistance exercise experience[30]. The exercise protocol of the 5 studies included was resistance training. Only one study investigated the chronic effects applying 8 weeks of resistance training[27], the others 4 studies investigated acute effects. All studies used repetition maximum (RM) to determine intensity of exercise. Three studies applied 30% of 1RM in BFR groups[26,27,30] and the others two studies used 20% of 1RM at BFR groups[28,29]. The study by Cezar *et al*., (2016) was the only to use a control group without BFR and without resistance exercises[27] and the study by Pinto *et al*., (2018) was the only to apply BFR in one group without resistance training[29]. The others three studies randomized individuals in two groups, one with BFR and resistance training and other without BFR but with resistance training[26,28,30].

Blood flow restriction methodology

Araujo *et al*., (2014) applied a sufficient pressure to occlude totally the leg arterial blood flow. The pressure was applied in both legs with 3 minutes of break between each measurement[26]. After that, 80% of

Figure 1. Flowchart of the process to select articles for systematic review.

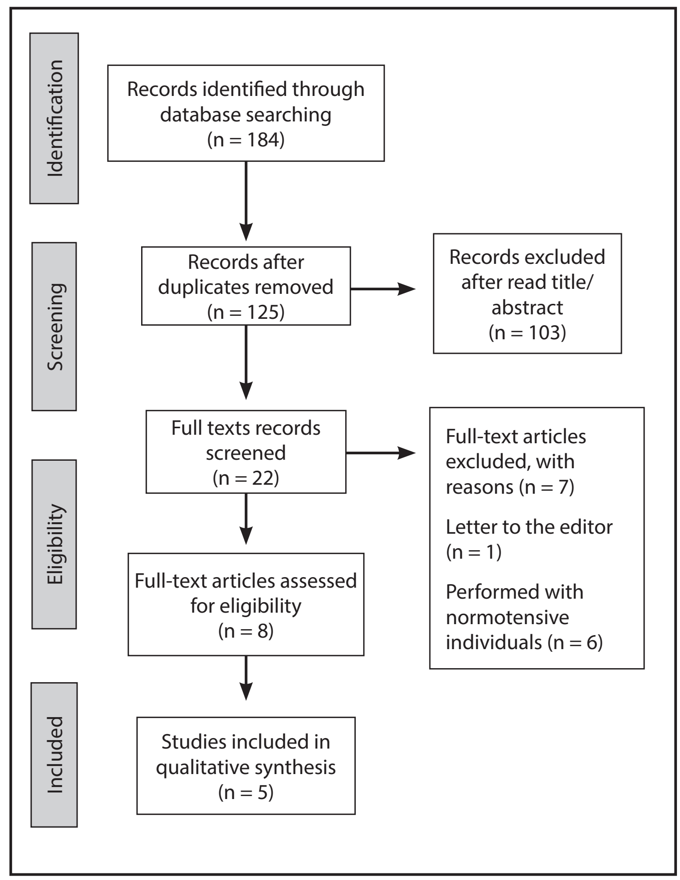

Table 1. Quality assessment of the studies using TESTEX checklist.

Study	1	2	3	4	5	6a	6b	6c	7	8a	8b	9	10	11	12	Total Score
Araújo *et al.*, (2014)	1	0	0	0	0	1	0	0	0	1	1	1	1	1	1	8
Cezar *et al.*, (2016)	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	14
Martins *et al.*, (2017)	1	0	0	1	0	0	1	1	0	1	1	1	1	1	1	10
Pinto *et al.*, (2018)	1	1	1	1	0	1	0	0	0	1	1	1	1	1	1	11
Pinto; Polito (2016)	1	0	1	1	0	1	0	0	0	1	1	1	1	1	1	10

1= Criteria met; 0= Criteria not met.

Table 2. Description of characteristics of the studies included.

Authors	Subjects/ Groups	Training Protocol	Cuff Method	Main Results
Araujo *et al.,* 2014	N = 14 Hypertensive women ST- MI (n = 7) ST-BFR (n = 7)	Acute RT-MI = 80% of 1RM RT-BFR = 30% of 1RM	Sphygmomanometers (18cm width x 80cm length)	↑SBP, DBP and HR during exercise for ST- BFR group compared to ST-MI group. ↓SBP, DBP, HR for 15, 30, 45- and 60-min post-exercise on ST-BFR. Hypotensive effect lasted for more than 60 minutes in the ST-BFR group, whereas in the ST-MI group it did not last less than 60 minutes.
Pinto and Polito., 2016	N = 12 Hypertensive women	3 randomized sessions RT-MI = 3x8, 65% de 1RM RT-BFR = 3x15, 20% de 1RM RT-LI = 3x15, 20% de 1RM	Blood pressure cuff for obese (10 cm width x 70 cm length) with a vascular doppler	↑ SBP, DBP, DP and SVR in ST-VO compared to RT-BFR with 20% of 1RM.
Cezar *et al.,* 2016	N = 23 Hypertensive women ST-HI (n = 8) ST-VO (n = 8) CTRL (n = 7)	Chronic study RT-BFR = 30%1RM RE-MI – 80%1RM	Sphygmomanometers (didn't relate measures)	↓ SBP, DBP MAP and DBP
Pinto *et al.,* 2018	N = 18 Hypertensive women	RT-MI = 3x15, 65%1RM RT-BFR = 3x15, 20%1RM Control = only BFR	Cuff + Vascular doppler (10cm width x 90 cm length)	↓ cardiac output, systemic vascular resistance and blood lactate in ST-VO, compared to ST-HI.
Martins *et al.*, 2017	N=10 Hypertensive men	2 sessions RT-BFR = 3 set at a concentric failure, 30% of 1 RM. RT-MI = 3 set at a concentric, 70%1RM	Elastic Belt (100mm width x 800mm length) with pneumatic bag	Both training protocols showed a significant decrease in SBP, DBP and HR after 10 min to 60 min, showing a greater reduction in ST-VO after 20 min post-exercise, compared to ST-HI.

ST: Strength training; MI: Moderate intensity; BFR: Blood Flow Restriction; CTRL: Control; 1RM: One Repetition Maximum; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HR: Heart Rate.

the pressure to totally occlusion was calculated and used. Cezar *et al.*, (2016) calculated the occlusion using 70% of SBP basal values[27]. Martins *et al.*, (2018) determined the SBP values at supine position and applied a pressure of 20 mmHg upper SBP values. The mean pressure of arterial occlusion was 159.2 ± 12.9 mmHg[30]. Pinto and Polito (2016) applied a pressure until the moment that the sound of blood flow could not be heard by a doppler equipment and this pressure was used at exercise protocol[28]. Pinto *et al.*, (2018) used 80% of the pressure necessary to full blood flow interruption[29].

Basal systolic blood pressure values

Of the studies included, all of them used individuals which underwent an anti-hypertensive therapy but only one study informed that individuals used Angiotensin II receptor class of medicaments[24].

The baseline hemodynamics value were reported by 3 studies[27–29]. The study by Cezar *et al.*, (2016) randomized individuals in three groups and the basal SBP value was 147.7 ± 2.84 mmHg for the group who received BFR and resistance training, 142.5 ± 3.46 mmHg for the group without BFR but with resistance training and 131.43 ± 4.44 mmHg for the control group[27]. The study done by Pinto and Polito (2016) recruited individuals with 128.7 ± 11.3 mmHg of SBP basal value[28]. And Pinto *et al.*, (2018) used individuals with 120.2 ± 3.4 mmHg of basal SBP[29].

Basal diastolic blood pressure values

For DPB values, Cezar *et al.*, (2016) used individuals with 92.75 ± 2.17 mmHg at BFR group resistance training, 89.25 ± 3.27 mmHg at group without BFR but with resistance training and 85.14 ± 3.29 mmHg at control group[27]. The basal values of DBP at Pinto and Polito (2016) study was 77.4 ± 9.7 mmHg[28] and at Pinto *et al.*, (2018) was 69.3 ± 1.8 mmHg[29].

Basal heart rate values

For Heart Rate values, only the same three studies report them. At Cezar *et al.,* (2016) study, individuals had 81.5 ± 4.93 BPM at BFR group and resistance training, 75.0 ± 3.78 BPM at the group without BFR but with resistance training and 71.4 ± 4.0 BPM at control group[27]. The study by Pinto and Polito (2016) used individuals with 76.6 ± 9.7 BPM[28] and the study by Pinto *et al.*, (2018) used individuals with 78.4 ± 2.1 BPM[29].

Effect of blood flow restriction on systolic blood pressure

Araujo *et al.*, (2014) measure hemodynamics values at pre-exercise and during the first, second and third set and 15, 30, 45 and 60 minutes post exercise[26]. For SBP values, was observed an increase in second set compared to first for group with BFR and during all moments of exercise the group with BFR had higher SBP valued than group without BFR. Cezar *et al.,* (2016) observed that after 8 weeks of training, only BFR was able to induce reduction in SBP (Pre moment: 145.75 ± 2.84 vs. Post moment: 129.75 ± 2.25)[27] Martins *et al.*, (2018) measured hemodynamics values at rest in supine position and after exercise with 10 minutes interval between measures until 60 minutes[30]. As observed by authors, immediately after exercise, SBP increased significantly but not differ between groups and 10 minutes after exercise, SBP returned to basal values and remained. The authors calculated the effect size of the results and only for BFR group was observed moderate or large reduction for SBP values at 20 and 40 minutes, respectively[30]. Pinto and Polito (2016) observed that the BFR induced an increase in SBP values when compared to a group without BFR and only the BFR induce increase in SBP during the rest between[28]. Pinto *et al.*, (2018) observed that during 3 sets the group with BFR had higher values of SBP than the group without BFR but after exercise they observed a significant reduction[29].

Effect of blood flow restriction on diastolic blood pressure

At the study of Araujo *et al.,* (2014) the DBP was higher during exercise for BFR group than for the group without BFR. But only at the second set was observed a statistical significance but only at the second set was observed statistical difference[26]. Cezar *et al.*, (2016) observed a significative reduction in DBP after 8 weeks of BFR resistance training[27]. Martins *et al.,* (2018) shown that immediately after exercise DBP increased significantly but not differ between groups and 10 minutes after exercise, DBP returned to basal values but only after 20 minutes of exercise DBP significantly reduced compared to basal values[30]. Pinto and Polito (2016) observed that the BFR induced an increase in DBP values when compared to a group without BFR and only the BFR induce increase in DBP during the rest between sets[28]. Pinto *et al.*, (2018) observed that DBP increase during 3 sets of resistance training with BFR compared to a group without BFR but similar to SBP, the levels of DBP significantly reduced after exercise[29].

Effect of blood flow restriction on heart rate

Only 4 studies reported the effects of BFR on Heart rate. At the study of Araujo *et al*., (2014) A significant increase in Heart Rate was observed between first and second set for the group with BFR[26]. Cezar *et al.*, (2016) observed that 8 weeks of resistance training with BFR was able to reduce heart rate values[27]. Pinto and Polito (2016) shown that BFR induced an increase in Heart Rate during 3 sets and returned to basal levels after exercise[28]. The study by Pinto *et al.,* (2018) reported an increase in heart rate during 3 sets with BFR but with a hypotension effect after exercise[29].

Discussion

To our acknowledgment, this is the first systematic review that investigated the blood flow resistance training safety on hypertensive subjects. The objective of this systematic review was to investigate the effects of BFR as another viable alternative in the treatment of systemic arterial hypertension. The studies about BFR in normotensive individuals demonstrated positive effects on blood pressure. Crisafulli *et al*., (2018) investigated the effects of 4 weeks of handgrip exercise with 40% of 1RM with BFR and was observed by authors that BFR were able to induce a reduction of mean arterial pressure response during handgrip exercise after 4 weeks[31]. The same results were observed by Neto *et al.,* (2015) which realize a study with 24 normotensive individuals submitted to a resistance exercise program and an hypotensive effect was observed after 30 minutes after resistance training with BFR[32]. According to authors, the hypotensive effect of BFR possible was mediated by a modification in baroreflex activity, with increased efficiency in buffering sympathetic activity[31] and an increase in nitric oxide production which was able to induce vasodilatation[32].

Despite these positive effects on normotensive individuals, until this review there is a lack of knowledge about the safety and efficacy of the BFR on SAH individuals. And according to our results, the major finding in this systematic review was the safety of BFR method applied in SAH individuals. As observed in included studies by Araujo *et al.*, (2014), Pinto *et al.*, (2018)[29], Martins *et al*., (2018)[30] and Pinto and Polito (2016)[28], there is an acute increase in SBP, DBP and HR levels during the sets of resistance exercise with BFR, but only in the study by Pinto and Polito (2016)[28] there is an increase in SBP and DBP higher than the increase in the group without BFR. These results could be explained because the authors used only 30 seconds of interval between 3 sets of 15 repetitions with BFR. So, this methodology of exercise with short rest interval (≤30 seconds) probably increased the accumulation of metabolites which is able to alter muscle recruitment and increase blood pressure mediated by exercise pressor reflex[33]. So, according to these results, for hypertensive individuals is not recommended use short rest intervals between sets when using BFR. But, based on the included studies, the BFR method with >40 seconds of rest interval between sets is safe for individuals with SAH.

Another acute positive effect of BFR method was the post-exercise hypotension. The study by Araujo *et al*., (2014), presented hypotensive effects 15, 30, 45 and 60 minutes after resistance training with BFR compared to a group without BFR[26]. And according to Martins *et al.,* (2018), 40 minutes after resistance training with BFR resulted in a reduction of DBP and SBP with a large effect size[30]. Unfortunately, these results were not supported by Pinto *et al.,* (2018)[29] and Pinto and Polito (2016)[28] which didn't present hypotensive effect after BFR training. These discrepancies in results could be explained by the rest interval used in Pinto and Polito (2016)[28] study and by the velocity of repetition used in Pinto *et al.,* (2018)[29] study which the authors used 2 seconds of concentric and 2 seconds of eccentric contractions. According to Apkrarian (2019) longer cadence of resistance exercise can increase hemodynamics value if compared to faster cadences[34].

But, despite these difference in methodology, Pinto and Polito (2016)[28] and Pinto *et al*., (2018)[29] compared the group with BFR to a group without BFR and loads of 65% of 1RM. According to the results, the increase in hemodynamics variables were similar between the groups. So, the resistance training with BFR did not increase the risk of cardiac events in patients with Hypertension.

Beside these acute results, one study included evaluated the chronic effects of BFR on SAH individuals. According to Cezar *et al.*, (2016) only the group submitted to a BFR training regimen for 8 weeks presented a reduction in hemodynamic variables. Additionally, the reduction in blood pressure after 8 weeks of BFR resistance training is due to an increase in vagal activity mediated by a hypoxia-induced oxidative stress, which is probably able to induce a chronic reduction in mean arterial blood pressure[27].

Some mechanisms could explain the benefits for blood pressure induced by low loads BFR training. When blood flow is restricted, there is a reduction in oxygen and energetic substrates delivery to the muscle. This delivery reduction is able to increase the levels of vascular endothelial growth factor and neuronal and inducible nitric oxide synthase[35]. These genes are responsible for angiogenesis[36] and this pro-angiogenic stimulus might reduce the progression of hypertension[37].

In another perspective, some cares need to be taken. For example, during the sets of resistance training with BFR was observed an increase in blood pressure as a consequence of the increased metabolites production and muscle metaboreflex[38]. So, in individuals with uncontrolled hypertension, is not recommended BFR training, mainly for the more pronounced increase in blood pressure. But, with pharmacological anti-hypertensive therapy and with controlled blood pressure, is safety to use BFR training.

Unfortunately, there are some limitations in this systematic review that must be highlighted: the number of studies about the effects of Blood flow restriction on individuals with SAH is scarce, mainly studies about chronic effect. Due to this, even with the studies included in this systematic review obtaining good methodological classification evaluated through of the TESTEX scale we cannot conclude about efficacy of the BFR in hypertensive individuals. In addition, there is still no standardization of the pressure exerted on the joints through the specific cuffs for the practice of BFR in hypertensive patients, each researcher used a means to determine the pressure exerted on the joints used in the exercises with BFR.

Conclusions

Through this systematic review, we can conclude that low load BFR training can be an alternative method of exercise for individuals with SAH, especially, in individuals with some frailty or some moderate and high load intolerance. Nevertheless, as consequence of the reduced numbers of studies included, we cannot conclude about the efficacy of the BFR on treatment of SAH. As future direction, studies comparing hemodynamic effects of small and large muscle groups with BFR and evaluating the metabolite levels after acute BFR in hypertensive individuals still needed. Another future direction is the urgence in chronic studies to understand the efficacy of this method to an alternative treatment for hypertension.

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Conflict of interest

The authors do not declare a conflict of interest.

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The effects of physical activity and eating habits on obesity levels among children aged between 6 and 12 years old: systematic review

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Feeding Habits. Physical Activity. Obesity. Children.

Summary

Introduction: Physical activity and eating habits are variables to take into account for the analysis and correction of obesity problems. The objective of this review was to evaluate the effects of physical activity and eating habits on obesity levels in children between 6 and 12 years of age.
Material and method: A bibliographic search was carried out in the WOS and SCOPUS databases. The eligibility criteria were established based on the acronym PICOS: (P) basic education children between 6 and 12 years of age, (I) studies that carried out interventions of the nutritional component, the physical activity component or a combination of both of them. This in the school, sports and / or family environment, (C) be subjected to evaluation using the PEDRO scale and obtain a score equal to or greater than 7, (O) evaluate the effect of food programs and / or physical activity on childhood obesity, (S) randomized controlled studies, published between 2015 and 2020.
Results: 6,388 articles were identified, but only those that met the inclusion criteria were included. but only those that met the inclusion criteria (34 studies) were included. The most effective interventions were found to be those combined with a medium duration of intervention, and parental involvement and gender may influence the effectiveness of these interventions.
Conclusion: Interventions that consider the component of physical activity and eating habits together are the most effective in achieving a decrease in obesity levels in children 6 to 12 years of age.

Efectos de la actividad física y hábitos alimenticios en los niveles de obesidad de niños entre 6 y 12 años: revisión sistemática

Resumen

Introducción: La actividad física y los hábitos alimentarios son variables a tener en cuenta para el análisis y corrección de los problemas de obesidad. El objetivo de esta revisión fue evaluar los efectos que tiene la actividad física y los hábitos alimentarios en los niveles de obesidad en niños entre 6 a 12 años de edad.
Material y método: Se realizó una búsqueda bibliográfica en las bases de datos WOS y SCOPUS. Los criterios de elegibilidad fueron establecidos en base al acrónimo PICOS: (P) niños de educación básica de entre 6 y 12 años de edad, (I) estudios que llevaran a cabo intervenciones del componente alimenticio, del componente de actividad física o una combinación de ambos. Esto en el ámbito escolar, deportivo y/o familiar, (C) ser sometidos a evaluación mediante la escala de PEDRO y obtener en esta un puntaje igual o superior a 7, (O) evaluar el efecto de los programas alimenticios y/o de actividad física sobre la obesidad infantil, (S) estudios controlados aleatorios, publicados entre los años 2015 y 2020.
Resultados: Se identificaron 6.388 artículos, pero solo se incluyeron los que cumplieron con los criterios de inclusión. pero solamente se incluyeron los que cumplieron con los criterios de inclusión (34 estudios). Se encontró que las intervenciones más efectivas fueron las combinadas con una duración de intervención media, y la participación de los padres y el sexo pueden influir en la efectividad de estas intervenciones.
Conclusión: Las intervenciones que consideran el componente de actividad física y hábitos alimenticios en conjunto son las más efectivas para logar una disminución de los niveles de obesidad en niños de 6 a 12 años de edad

Palabras clave:
Actividad Física. Hábitos Alimenticios. Obesidad. Niños.

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Introduction

According to the World Health Organization (WHO),[1] non communicable diseases (NCD) are responsible for an annual mortality level of 41 million people, corresponding to 71% of deaths throughout the world. NCD are known as chronic diseases, they are generally long duration and have negative consequences in all age groups and all countries. They emerge due to the presence of various risk factors, such as modifiable behaviour and metabolic factors. In terms of metabolic risk factors, one of the main causes of death worldwide is rising blood pressure (19%), followed by excess weight and obesity. The latter is defined as an abnormal or excessive accumulation of fat that presents a health risk.[2]

According to Oyarce, *et al.*,[3] this is characterised by an excessive increase in the percentage of body fat, produced by a positive energy balance sustained over time, capable of causing other diseases to appear, as mentioned by Schetz, *et al.*,[4] who determine that depending on the degree, distribution and duration of the excess body fat, the health risks include the appearance of hypertension, type II diabetes, cardiovascular diseases, dyslipidaemia, chronic renal diseases, non-alcoholic fatty liver, obstructive sleep apnea or hypoventilation, physical and mood-related disorders. Regarding its prevalence throughout the world, Jaacks, *et al.*,[5] mention that it has increased substantially over the last few decades from under 3% in 1975 to 11% in 2016 among men and from 6% to 15% among women; in the case of children, the increase went from 1% to 6-8% during the same period of time. In this context, the WHO[6] highlights that child obesity has become one of the most serious public health issues in the 21st century. This worldwide problem is progressively affecting a large number of low and medium-income countries. Indeed, from 2014 onwards, the prevalence of obesity in subjects from 2 to 19 years old is 17%.[7] In fact, it is calculated that in 2016, more than 41 million children aged under five throughout the world were overweight or obese.[6] Chile has not escaped this phenomenon and excess weight and obesity have increased among schoolchildren and the population aged over 15 years old in Chile over the last few decades, despite prevention work.[8] Furthermore, according to Sapunar, *et al.*,[9] this progressive increase in the prevalence of disorders due to overnutrition has become one of the highest in the world. Something similar has happened among the child-youth population both in Santiago and in the regions. In fact, Bustos, *et al.*[10] mention that the Junta de Auxilio Escolar y Becas (School Assistance and Grants Board) (JUNAEB), a Chilean Government institution, demonstrated that, during 2013, the obesity level among children aged 6 who were attending the first year of basic schooling was 25.3%. In general terms, low levels of physical activity and an increase in sedentary behaviour are the most important causes of obesity. Indeed, according to Blanco, *et al.*,[11] there is a direct relationship between sedentary behaviour and fat accumulation. In this respect, Aguilar, *et al.*[12] indicate that physical activity corresponds to any body movement performed by the skeletal muscles that requires energy such as tasks performed every day in the home, work, leisure and transport. It can provide various benefits for mental and physical health when children do 60 minutes of moderate to vigorous physical activity per day. Despite these benefits, Watson, *et al.*[13] show that more than 50% of the child population in Australia and internationally do not meet these recommendations. This data is a cause for concern, due to findings which suggest that functional limitations, subjective well-being, social support, memory, depression and age are associated with physical inactivity and are therefore potential factors on the path to poor health.[14] According to Gallota, *et al.*,[15] the prevalence of inappropriate eating habits such as consuming many snacks and sugary drinks mid-morning, skipping breakfast, eating less fruit and/or vegetables can cause an increase in weight among children. Regarding the latter, Seidell and Halberstadt[16] suggest that the increase in obesity levels in most countries seems to be mainly caused by changes to how food is supplied worldwide, offering a larger quantity of processed food which is more affordable and more widely sold than before. There are various definitions of eating habits, due to a wide variety of concepts. However, according to Pereira-Chávez, *et al.*,[17] most concur that these are frequent manifestations of individual and collective behaviour that is acquired directly and indirectly and that are related to what is eaten, how, when, with what, for what and who eats the food.

Based on Viljakainen, *et al.*,[18] a healthy diet, based on appropriate consumption of fruit, vegetables, fish, poultry, whole cereals and low-fat dairy products reduce the risk of obesity in adult and paediatric populations while an unhealthy diet rich in processed meat, refined cereals, sweets, food containing starch and high fat dairy products has been associated with excess weight. Consequently, eating habits recommended for children must provide the necessary energy, nutrients and bioactive compounds to keep them in good health.[19] These data raise the following questions:

What are the effects of physical activity on obesity in children between 6 and 12 years old?

What are the effects of eating habits on obesity in children between 6 and 12 years old?

In this context, the aim was to evaluate the effects of physical activity and eating habits on obesity levels in children between 6 and 12 years old.

Material and method

Search strategy

This study is a systematic review that followed the PRISMA guide and the PICoR questions model to select the keywords. A search was performed on the Cochrane Library, Pubmed, and Wiley Library databases, that included papers published from 2015 to 2020. The search criteria included logically combining the DeCS search terms, using the respective Boolean search engines. Consequently, the following keywords were used for the search: “Eating habits”, “Physical activity”, “Obesity” and “Children” in Spanish and English. The information search and extraction took place between August and October 2020, and it was stored in the Mendeley bibliographic quotes manager. The results were filtered by documents with the main theme of evaluating the effects of eating habits and physical activity on child obesity levels.

Inclusion criteria

- Random controlled studies, so that the study groups have equivalent characteristics, and any possible selection bias is avoided.
- Topics address eating habits, use of diets, physical activity and multidisciplinary interventions that included these variants, to treat excess weight or obesity and their effect on these factors in children aged between 6 and 12 years old, both female and male.
- Some type of result is obtained regarding indicators related to obesity.
- Once the search had been run, the quartile (Q) of the journal was identified, selecting any that are Q1 and Q2 in the Scopus database.
- Researchers from this systematic review have methodologically assessed it using the PEDro scale to quickly identify studies that tend to be validated internally and which have sufficient statistical information to develop this review.

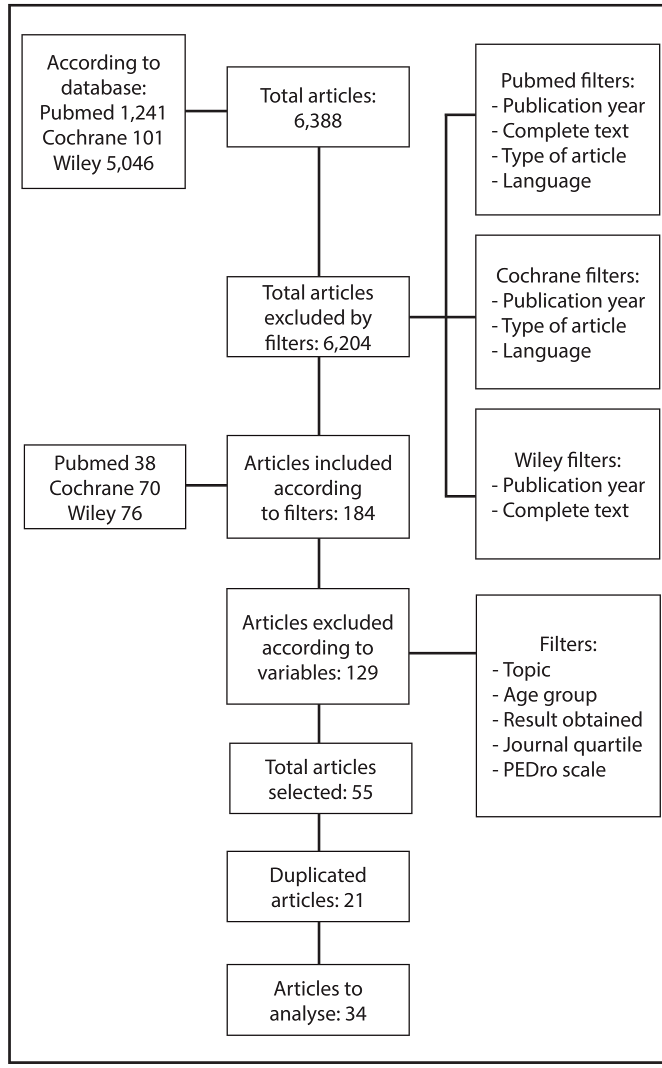
All articles that did not meet these criteria were excluded. A total of 6,388 articles were identified on the "Pubmed", "Cochrane Library" and "Wileylibrary" platforms, (1,241, 101 and 5,046 studies respectively). The total number of articles excluded by the platform filters was 6,204, including 184 studies to be reviewed, which were verified by title, keywords and study abstract. From this quantity, 128 studies were excluded due to the initially-categorised variables (age group, result obtained, unrelated studies), leaving a total of 56 selected studies of which 21 were duplicated, concluding with the total of 34 articles included in this research (Figure 1).

Results

Data was extracted from the selected articles that met the inclusion criteria. Tables 1 and 2 describe relevant information from the studies, identifying the name of the research, authors and year of publication, plus its duration, location and results of the intervention.

34 random controlled studies were included. To define the ranges in relation to the time frames corresponding to the research, we call on the standard used in the systematic review of Effective techniques for changing behaviour for physical activity and healthy eating among adults who are overweight or obese.[53] Short-term research (n = 15) refers to lasting 6 months or less (44.12%), medium-term (n = 7) lasts over 6 months, but under 12 months (20.59%), and long-term (n = 11) refers to research lasting for 12 months or more (32.35%). One study did not specify how long it lasted (2.94%). The sample size makes it possible to demonstrate how many individuals must be studied to be able to detect a certain difference between the groups. Female and male children took part in the following review and the highest research sample size was 10,091, compared to the lowest which was 29.

Figure 1. Process for including the articles.



The included studies consisted of 34 random controlled studies. A large number of them (n = 12) took place in Europe (35.29%), followed by North America with 9 studies (26.47%), and Asia also with 9 studies (26.47%), Oceania with 2 (5.89%), Africa 1 (2.95%) and South America also with 1 study (2.9%).

The included studies involved interventions on the food component, physical activity and a mixed component. Seven studies carried out interventions on physical activity without a food intervention (20.5%). The same number of studies (n = 7) only carried out interventions on the food component (20.5%). Twenty studies carried out mixed or multidisciplinary interventions, that included both the food and the physical activity component (59%). These included studies produce different results relating to different anthropometric values for the study subjects, such as body weight, body mass index (BMI), body fat percentage, waist circumference, skin folds, body lean mass and fat mass; plus statistical

Table 1. Duration of the intervention and sample size.

Authors and year	Duration	Sample size (n)
Kühr, *et al*. (2020)[20] Denmark	5 years	1,299
Cao, *et al.* (2015)[21] China	33 months	2,446
Ochoa-Avilés, *et al*. (2017)[22] Ecuador	28 months	1,430
Hollis, *et al.* (2016)[23] Australia	24 months	1,150
Katan, *et al.* (2016)[24] Netherlands	18 months	641
Makkes, *et al*. (2016)[25] Netherlands	12 months	80
Cohen, *et al*. (2016)[26] Canada	12 months	78
Adab, *et al*. (2018)[27] United Kingdom	12 months	2,562
Anderson, *et al*. (2017)[28] New Zealand	12 months	203
Fulkerson, *et al.* (2015)[29] United States	12 months	160
Li, *et al.* (2019)[30] China	12 months	1,641
Xu, *et al.* (2015)[31] China	1 academic year	1,182
Wang, *et al.* (2018)[32] China	1 academic year	10,091
Kesztyüs, *et al.* (2017)[33] Germany	1 academic year	1,733
Lima, *et al.* (2020)[34] Switzerland	9 months	499
Sánchez-López, *et al*. (2020)[35] Spain	9 months	108
Serra-Paya, *et al.* (2015)[36] Spain	8 months	113
Yu, *et al.* (2020)[37] China	8 months	171
Boutelle, *et al.* (2017)[38] United States	6 months	150
Bibiloni, *et al.* (2019)[39] Spain	6 months	140
Yusop, *et al.* (2018)[40] Malaysia	6 months	50
Staiano, *et al*. (2018)[41] United States	6 months	46
Seo, *et al.* (2019)[42] Korea	4 months	103
Nicolucci, *et al.* (2017)[43] Canada	4 months	42
Ahmad, *et al.* (2018)[44] Malaysia	4 months	134
Koo, *et al.* (2018)[45] Malaysia	3 months	83
Moschonis, *et al*. (2019)[46] Greece	3 months	80
Cvetković, *et al.* (2018)[47] United States	3 months	42
Muller, *et al.* (2019)[48] South Africa	2.5 months	746
Morell-Azanza, *et al*. (2019)[49] Spain	2 months	121
Ojeda-Rodríguez, *et al.* (2018)[50] Spain	2 months	107
Wang, *et al.* (2019)[32] United States	1.5 months	110
Bogart, *et al*. (2016)[51] United States	5 months	4,022
Baum, *et al*. (2015)[52] United States	Not indicated	29

results such as the BMI z-score, body weight z-score, probability of developing obesity and percentage of individuals with normal weight. Furthermore, some studies revealed results on fat oxidation levels and triglyceride levels (Table 3).

The included studies comprised 34 random controlled studies. 7 of them only performed interventions on the food component, of which 4 carried out a direct intervention on the food intake by the study subjects (11.8%) while the remaining 3 were based on recommendations and theory classes on this component (8.8%).

Table 2. Types of interventions and results obtained in the studies.

Authors and year	Intervention	Results
Wang, *et al.*[32] (2018) China	Physical activity	Lower BMI and probabilities of obesity
Kühr, *et al.*[20] (2020) Denmark	Physical activity	Lower BMI and WC
Cvetković, *et al.*[47] (2018) United States	Physical activity	Trivial drop in body mass, increase in muscle mass, lower fat mass and BMI.
Hollis, *et al.*[23] (2016) Australia	Physical activity	Lower average weight and BMI
Muller, *et al.*[48] (2019) South Africa	Physical activity	Smaller increase in average BMI-z and a smaller increase in the average thickness of skin folds.
Lima, *et al.*[34] (2020) Switzerland	Physical activity	Smaller sum of skin folds
Staiano, *et al.*[41] (2018) United States	Physical activity	Lower BMI z-score. Better LDL and total cholesterol
Fulkerson, *et al.*[29] (2015) United States	Physical activity	Drop in excess weight. Lower BMI z-scores. Drop in weight gain for overweight children
Wang, *et al.*[54] (2019) United States	Dietetics	Lower BMI-z, increase in physical activity, consumption of fruit and vegetables
Baum, *et al.*[52] (2015) United States	Dietetics	Increase in fat oxidation, satiation, less hunger.
Katan, *et al.*[24] (2016) Netherlands	Dietetics	Lower increase in the BMI z-score and body weight. Drop in body fat in the high BMI group.
Nicolucci, *et al.*[43] (2017) Canada	Dietetics	Lower z-score for body weight, the percentage of body and trunk fat
Koo, *et al.*[45] (2018) Malaysia	Dietetics	Lower percentage of body fat, WC
Ochoa-Avilés, *et al.*[22] (2017) Ecuador	Dietetics	Drop in WC after stage one
Bogart, *et al.*[51] (2016) United States	Dietetics	Reduction in the BMI percentile for obese students after 2 years
Moschonis, *et al.*[46] (2019) Greece	Mixed	Lower BMI and BMI z-score. Less increase in body weight and WC
Xu, *et al.* (2015)[31] China	Mixed	Lower BMI and increase in the chances of reducing the BMI
Makkes, *et al.*[25] (2016) Netherlands	Mixed	Lower BMI-SD due to an average weight loss
Ojeda-Rodríguez, *et al.*[50] (2018) Spain	Mixed	Lower body weight, BMI-SD, glucose, total cholesterol levels and total energy intake

(continued)

Table 2. Types of interventions and results obtained in the studies (continuation).

Authors and year	Intervention	Results
Yusop, *et al.*[40] (2018) Malaysia	Mixed	Lower BMI z-score. Increase in the physical activity level from low to moderate.
Cohen, *et al.*[26] (2016) Canada	Mixed	Lower BMI z-score and fat mass percentage. Lower fat mass and increase in lean mass
Bibiloni, *et al.*[39] (2019) Spain	Mixed	Overweight participants changed to normal weight after 6 months
Sánchez-López, *et al.*[35] (2020) Spain	Mixed	Drop in the percentage of average body fat, average BMI and kilograms of body fat
Adab, *et al.* (2018)[27] United Kingdom	Mixed	Average BMI z-score was lower in the intervention group
Anderson, *et al.*[28] (2017) New Zealand	Mixed	Significant drop in the BMI-SD
Li, *et al.*[30] (2019) China	Mixed	Lower BMI z-score and fat percentage
Ahmad, *et al.*[44] (2018) Malaysia	Mixed	Lower BMI z-score and body weight. Smaller increase in the average WC percentile
Cao, *et al.*[21] (2015) China	Mixed	Drop in the prevalence of obesity and BMI z-score. Increase in the percentage of individuals with normal weight
Boutelle, *et al.*[38] (2017) United States	Mixed	Lower BMI-z
Kesztyüs, *et al.*[33] (2017) Germany	Mixed	Drop in the BMI percentile and the probabilities of developing abdominal obesity during the study period.
Morell-Azanza, e*t al.*[49] (2019) Spain	Mixed	Drop in the BMI-SD and hip circumference
Seo, *et al.*[37,42] (2019) Korea	Mixed	Lower BMI-z, fat mass and blood pressure
Yu, *et al.*[37] (2020) China	Mixed	Drop in the risk of metabolic anomalies. Lower increase in TG.
Serra-Paya, *et al.*[36] (2015) Spain	Mixed	Drop in BMI-d and increase in physical activity

Seven studies performed interventions on physical activity without a food intervention, and all of them carried out a direct intervention that implied doing different types of physical activity at different frequencies (20.5%).

The other studies (n = 20) carried out mixed interventions, of which 4 were based on recommendations and theory sessions on these components (11.8%) while the remaining 16 (47.1%) carried out a direct intervention on the subjects' food and their levels of physical activity.

Discussion

34 random studies were analysed that examined the effect of eating habits and physical activity to address excess weight and obesity in children aged between 6 and 12. Research was included with an intervention time from 5 weeks to 5 years, consequently, it was classified into short-term (44.12%), medium-term (20.59%) and long-term (32.35%) to ease data interpretation. Only one study did not present an intervention time (2.94%). The interventions in the included studies varied from short to long term, mainly in relation to sample size, as the average for long-term research is 1,062 participants, as opposed to medium-term, where the average was 1,985 and short-term with an average sample size of 373 participants. In relation to this data, Das, *et al.*[55] state that a correct sample size reduces the random error or prevents chance events. Furthermore, samples which are too small in general do not answer the research questions and can deliver an inaccurate answer. On the contrary, while a large sample does deliver answers to the research questions, it might not be particularly ethical. Based on this topic, Heidel[56] suggests that the larger the sample size, the higher the chances of detecting significant effects, that make it possible to detect small and large effect sizes, independently of their respective variations. However, this is counter-balanced by Sones, *et al*.,[57] who state that large sample studies can waste a large number of resources and in turn, can give false results. On the other hand, out of the 34 research projects included, 21 (61.76%) demonstrated a greater effect on obesity indicators. Out of these 21, 6 were long-term, 2 were medium-term and the largest concentration of studies with important effects was 13, which were short-term. This indicates that the most effective type of interventions usually last 6 months or less. This data contrasts with Aguilar, *et al.*[58] who suggest that short-term interventions or any that take place outside the children's daily activities, produce a clear rebound effect in the results obtained. To this we can add that, regarding the location of the selected studies, most of the interventions took place in Asia or Europe, and our continent (South America) presented the smallest number of studies of this type. This means that more interventions are required to evaluate whether the benefits observed in the review studies are just as effective among children with the genetic, environmental and sociocultural characteristics found in our country, as in the case of the pilot study by Mardones, *et al.*[59], which implemented an intervention based on physical activity among school children aged 6 and 7 years old, obtaining favourable results in variables such as blood pressure and waist circumference. This need increases, because South American countries demonstrate particular characteristics related to eating habits and physical activity, as indicated in the study by Louzada, *et al.*[60] which mentions that ultra-processed food represented 30% of the total energy contribution in Brazil, and this correlated with high BMI levels. On the

Table 3. Effectiveness of the physical activity programmes and nutritional mediation.

Authors and year	Physical activity intervention	Nutritional mediation
Wang, *et al*. (2017) China	Study plans in the classroom, support for the school environment, family participation and fun programmes/events.	None
Kühr, *et al*. (2019) Denmark	4.5 hours of physical education classes a week	None
Cvetković, *et al*. (2018) United States	HIIT training and recreational football	None
Hollis, *et al*. (2016) Australia	Teaching strategies for physical activity (PA), PA plans, school sports programme, PA exhibitions and PA programmes during the school holidays.	None
Muller, *et al*. (2019) South Africa	Two 40-minute physical education lessons per week; one 40-minute music and movement per week; regular physical activity breaks in class; setting up activity stations and a variety of playground painted games.	None
Lima, *et al*. (2020) Switzerland	Two additional physical education lessons per week.	None
Staiano, *et al*. (2018) United States	Videogames that implicate physical activity, plans for game studies and videochat sessions with a physical trainer.	None
Fulkerson,*et al*. (2015) United States	None	Family-based change in the planning, frequency and healthy aspect of meals.
Wang, *et al*. (2019) United States	None	Group sessions on nutrition
Baum, *et al*. (2015) United States	None	Eating protein-based breakfasts
Katan, *et al*. (2016) Netherlands	None	Replacing sugary drinks with non-calorific drinks
Nicolucci, *et al*. (2017) Canada	None	Intake of prebiotic doses (8 g a day)
Koo,*et al*. (2018) Malaysia	None	Nutritional education classes and handing out wholemeal food
Ochoa-Avilés, *et al*. (2017) Ecuador	None	Classes and workshops on healthy eating, workshops for parents and preparing healthy breakfasts.
Bogart, *et al*. (2016) United States	Encouraging physical activity using posters, short films,	Stimulus for eating healthy food in the school canteen, education and peer-based marketing
Moschonis, *et al*. (2019) Greece	Physical activity recommendations	Personalised eating plans and nutritional recommendations
Xu, *et al*. (2015) China	Lessons on physical activity, posters to promote physical activity and lessons for parents or tutors.	Lessons on healthy eating, posters to promote healthy eating and lessons for parents or tutors.
Makkes, *et al*. (2016) Netherlands	Sessions on physical activity and sports games	Classes on nutrition
Ojeda-Rodríguez, *et al*. (2018) Spain	Physical activity recommendations	Use of the Mediterranean diet and nutritional recommendations
Yusop, *et al*. (2018) Malaysia	Aerobic training sessions	Nutritional advice and a practical activity to prepare healthy food
Cohen, *et al*. (2016) Canada	Family advice sessions on physical activity, 60 minutes of activity per day based on jumping, running or light strength-training activities.	Family-based sessions on nutritional advice, consumption of 2 to 4 portions of dairy per day, colour coding food according to calorie content
Bibiloni, *et al.* (2017) Spain	5 or more hours of physical activity in a sports centre.	Use of the Mediterranean diet, attending dietary clinics.
Sánchez-López, *et al*. (2020) Spain	90-Minute physical activity sessions based on games	Theoretical sessions and nutritional advice practice
Adab, *et al*. (2018) United Kingdom	Recommendations for physical activity, one additional class per week of physical activity lasting 30 minutes at school, interactive programme with a football club.	Family workshops on healthy cooking.

(continued)

Table 3. Effectiveness of the physical activity programmes and nutritional mediation (continuation).

Authors and year	Physical activity intervention	Nutritional mediation
Anderson, *et al.* (2017) New Zealand	Family-based physical activity sessions, including sports chosen by the participants.	Assessment evaluations for all participants, through virtual paths round supermarkets, cooking sessions, portion sizes, and concept of healthy food.
Li, *et al*. (2019) China	Moderate to Vigorous Physical Activity sessions (MVPA)	Lessons and encouragement for healthy eating behaviour inside and outside school.
Ahmad, *et al.* (2018) Malaysia	Exercise session of moderate to intense physical activity lasting at least 30 minutes and up to 120 minutes of screen time (TV or videogames).	Skills training for parents on their children's diet through specific daily behaviour for the child such as avoiding sugary drinks and unhealthy snacks, eating at least five portions of fruit and vegetables (two portions of fruit and three portions of vegetables).
Cao, *et al.* (2015) China	Weekly exercise sessions by applying the 20-metre musical shuttle, 2 or 3 times a week. Ensuring the participation rate for regular physical education at school and out of school activities. More than 1 hour of physical activity every school day and outstanding sports activities such as skipping and football.	Monitoring students' eating speed during lunch and advice on how to eat less junk food. Reducing the fat content in food in the canteen and making sure that there are more fruit and vegetables available.
Boutelle, *et al.* (2017) United States	Recommendation of moderate to vigorous physical activity to parents, to apply to their children.	It was assessed with three dietary reminders with multiple 24-hour passes in 3 non consecutive days through a phone interview. The total energy intake was calculated using the Nutrition Data Systems for Research software.
Kesztyüs, *et al*. (2017) Germany	Physical activity sessions, focussed on parents and children, from moderate to vigorous intensity.	Guidance to reduce the intake of sugary drinks.
Morell-Azanza, *et al.* (2019) Spain	Individual and group sessions of moderate to vigorous physical activity with weekly measuring using an axial accelerometer.	High consumption of fruit (3 portions a day), vegetables (2 portions a day), pulses, whole grains and olive oil; moderate consumption of dairy, poultry and fish, and less processed and red meat, limited to 1 portion per week.
Seo, *et al.* (2019) Korea	Assessment related to physical exercise by health professionals. All the participants received instructions to walk more than 8000 steps a day and they were sent a text message once a week to encourage daily physical activity.	Personalised medical advice, providing a workbook to set goals and change behaviour, assessment on personalised nutritional advice.
Yu, *et al*. (2020) China	Compulsory daily exercise was implemented. This consists of a 20-minute break in classes in the morning to go jogging. An additional gym class (40 min) after school in the afternoon included three types of exercises (skipping, badminton and 200 m relay races).	Promoting intake of healthy food and developing healthy eating habits.
Serra-Paya, *et al*. (2015)	The programme offered 90 one-hour sessions (3 per week) of moderate physical activity for children.	Guidance and assessment on consumption of fruit, processed meat, excess food and soft drinks.

other hand, the study performed in Chile by Delgado-Floody, *et al.*[61] determined that physical condition variables differed significantly between the study subjects, which were 100 children aged between 12 and 15. This variable has an inverse relationship with obesity levels according to Zurita-Ortega, *et al.*,[62] which included a group of children with an average age of 10.5 years old and it established a negative relationship between the BMI and the maximum oxygen consumption, jumping ability, physical activity and self-esteem among these subjects. Apart from this, the socio-economic situations are varied and differ from other continents, which might affect obesity levels,[63] where it indicates that the socio-economic level in childhood influences the body mass index, waist circumference and obesity in adults, and that this relationship would differ between genders. All the studies included (n=34) provided information on some type of effect of the intervention on at least one indicator related to obesity, where BMI and values related to this indicator, such as the BMI z-score (BMI-z) and the standard deviation of the BMI (BMI-SD) are the most common focus. In turn, it was identified that the higher number of studies which obtained significant results (n = 21) had a mixed intervention (n = 15), which indicates that interventions combining the physical activity component and the diet component are the most effective to address child obesity. These findings are consistent with other similar research, such as Thakur, *et al.*[64], which demonstrated that a package of lifestyle interventions based at school had a favourable effect on the anthropometric parameters in a group of children with the average age of 13 years old. There is also the study by Ranucci, *et al*.,[65] which demonstrates the efficacy of a multidisciplinary intervention in reducing the cardiometabolic risk, significant drop in BMI, body fat percentage and waist circumference in children (5 to 12 years old); and in the case of teenagers (13 to 17 years old), a drop in waist circumference (WC) and body fat percentage.

In turn, this is explained by the results obtained in a study in Spain by Ruiz, *et al*.[66], which indicate that excess calorie intake is not the main reason explaining the high predominance of excess weight or obesity, but it goes hand in hand with a sedentary lifestyle and low levels of physical activity. Interventions carried out on the study subjects were run or jointly run mainly by school staff (teachers), external professionals who specialise in health (dieticians, nurses, paediatricians, psychologists, physiotherapists, nutritionists, doctors, sports medicine specialists), in the social area (social workers), in the physical activity area (physical trainers), by research personnel, university students or leading colleagues. In some cases, there was a combination of different types of professionals. Only one study did not specify who performed the intervention, only that it was supervised by research personnel. The implementation of interventions that involved a multidisciplinary approach regarding the professionals in charge were demonstrated to be effective to address obesity, which concurs with the indications provided by Fitzpatrick, *et al*.,[67] determining a model for handling obesity in primary care, based on the 5A assessment framework (assess, advise, agree, assist and arrange), and in its second point, they indicate that: a multidisciplinary team is required to help patients lose weight and maintain their weight loss. In the same way, studies are included that consider participation from family members (parents or tutors) in the applied intervention (n = 26), of which 18 correspond to studies that had an important effect on the obesity indicators. This inclusion is upheld by Gerards, *et al*.,[68] who mention that focussing on styles of child-raising seems to be effective to prevent or treat child obesity and thereby improve the results for children and parents, and also the eating habits and levels of physical activity for the children. Based on the studies that include parents or tutors as mentioned above, the majority demonstrate positive effects on modifying indicators related to obesity. This is upheld by a study performed in Korea, where the results obtained indicate that a parent participation programme combined with an exercise and nutrition intervention for the children was more effective for both parents and children than the intervention only offered to children.[69]

In the same way, Ek, *et al*.[70] implemented an intervention for parents of obese children aged between 4 and 6, which was demonstrated to be more effective than the standard treatment for obesity in pre-school children, after 12 months. In fact, it was seen to be 5 times more likely to get a clinically significant drop in the BMI-z score compared to the standard treatment. Within our study, we can see certain limitations that mainly lie in low sample sizes and the short duration of some interventions, which might not identify significant relationships between the intervention and the effect. Furthermore, few studies were carried out in continents such as Oceania, Africa and South America, to confirm results in more varied samples with different ethnic and racial origins, where behaviour and cultural beliefs differ regarding physical activity and eating habits.

Conclusion

According to the data analysed in this systematic review, it can be concluded that interventions which jointly consider the physical activity and eating habit components are the most effective to lower obesity levels among children aged 6 to 12 years old, recommending an intervention duration of 6 months or less, carried out by a multidisciplinary group of professionals and including participation from parents, to guarantee good results.

Authorship contribution

All the authors of this paper have taken part in the design, search for information, interpretation of the information, writing the text in all the versions completed and finally in the approval of the final version of the paper.

Conflict of interests

The authors do not declare any conflict of interests.

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If there should be any relation between the work's authors and any public or private entity, from which a conflict of interests could appear, it must be communicated to the Editor. Authors must fulfil a specific document.

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All authors that sign the articles accept the responsibility defined by the World Association of Medical Editors.

The papers sent to the journal for evaluation must have been elaborated respecting the international recommendations about clinical and laboratory animals' researches, ratified in Helsinki and updated in 2008 by the American Physiology.

For the performance of controlled clinic essays the CONSORT normative shall be followed, available at http://www.consort-statement.org/

Campaña de aptitud física, deporte y salud

La **Sociedad Española de Medicina del Deporte**, en su incesante labor de expansión y consolidación de la Medicina del Deporte y, consciente de su vocación médica de preservar la salud de todas las personas, viene realizando diversas actuaciones en este ámbito desde los últimos años.

Se ha considerado el momento oportuno de lanzar la campaña de gran alcance, denominada **CAMPAÑA DE APTITUD FÍSICA, DEPORTE Y SALUD** relacionada con la promoción de la actividad física y deportiva para toda la población y que tendrá como lema **SALUD – DEPORTE – DISFRÚTALOS**, que aúna de la forma más clara y directa los tres pilares que se promueven desde la Medicina del Deporte que son el practicar deporte, con objetivos de salud y para la mejora de la aptitud física y de tal forma que se incorpore como un hábito permanente, y disfrutando, es la mejor manera de conseguirlo.

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Regulador Altitud/Flujo	Manual/Manual, permite regular altitud y flujo	Manual/Electrónico, permite regular altitud y flujo
Aire hiperóxico	Sí. Máximo 10 l/min.	Sí. Máximo 5 l/min.
Medidas/Peso	36 cm x 40 cm x 65 cm / 30 kg	33 cm x 20 cm x 50 cm / 11 kg
Nivel Sonoro	50 dB de base y picos de 65 dB	45 dB de base y picos de 65 dB
Bolsa Expansión	Incluida. 60 litros de capacidad	Incluida. 60 litros de capacidad
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