ISSN: 0212-8799

174

Volume 33(4)
July - August 2016

Archivos de medicina del deporte

Órgano de expresión de la Sociedad Española de Medicina del Deporte

ORIGINALS

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Publicidad
ESMON PUBLICIDAD
Tel. 93 2159034

Publicación bimestral
Un volumen por año

Depósito Legal
Pamplona. NA 123. 1984

ISSN
0212-8799

Soporte válido
Ref. SVR 389

Indexada en: EMBASE/Excerpta Medica, Índice Médico Español, Sport Information Resource Centre (SIRC), Índice Bibliográfico Español de Ciencias de la Salud (IBECS), y Índice SJR (SCImago Journal Rank).

La Revista Archivos de Medicina del Deporte ha obtenido el Sello de Calidad en la V Convocatoria de evaluación de la calidad editorial y científica de las revistas científicas españolas, de la Fundación Española para la Ciencia y la Tecnología (FECYT).

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Anterior Knee Pain: A Paradigm of Aversion Towards a Pathology

Dolor anterior de rodilla: un ejemplo de aversión hacia una patología

Vicente Sanchis-Alfonso

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"That those who know her, know her less, the nearer her they get"
Emily Elizabeth Dickinson

Anterior knee pain (AKP) is very common in the general population, causing chronic disability, lost time from work, limitations in participating in sports, and a diminished quality of life. AKP represents one third or more of all complaints in a sports medicine clinic. In a study on participants from the U.S. Naval Academy, Boling *et al*.[1] found an AKP prevalence of 15% in females and 12% in males. They also observed that the annual incidence of AKP was 33 of 1000 people in female patients and 15 of 1000 people in male patients. Nevertheless, in spite of its high incidence and prevalence, the etiology of AKP is obscure, which complicates treatment and hinders recovery. In a multicentre observational analysis study, Collins *et al*.[2] showed that 40% of patients had an unfavourable recovery at 12 months after the initial diagnosis. Moreover, AKP is recurrent or chronic in 70% to 90% of individuals with the condition[3]. The etiology of AKP is multifactorial, with not only local (e.g., knee) factors but also proximal (e.g., hip and trunk) and distal (e.g., foot and ankle) ones. In fact, in many patients the primary cause of AKP does not lie within the patellofemoral joint, and there are several subgroups within the AKP population. Therefore, the best treatment must be tailored to individual patients. Among all the subsets of patients with AKP, the most challenging type of AKP, from a therapeutic point of view, is neuropathic. Once conventional treatments have failed in these patients, alternatives such as radiofrequency neurotomy and the repetitive transcranial magnetic stimulation can be considered[4]. We are currently exploring these techniques in our work group in this subset of patients.

"Chondromalacia patellae" (soft cartilage on the knee cap) was previously used as a catch-all term for any pain in the anterior aspect of the knee, but the term has been replaced by "patellofemoral pain syndrome" in reference to patients with AKP. However, neither term expresses a diagnosis but rather presents an admission of ignorance. Not all the patients with AKP have chondromalacia patellae, and many patients with chondromalacia patellae do not have from AKP. For example, van der Heijden *et al*.[5] have not found any differences in the patellofemoral cartilage composition between AKP patients and healthy controls. Further, even patients with severe patellofemoral chondropathy may not have knee pain. Consequently, the International Patellofemoral Study Group advises against using these terms as a diagnosis and suggests that "anterior knee pain" might be better because it is descriptive, without implying anything more.

Yet, AKP is a pathology in which numerous clichés and false beliefs coexist. One of the clichés is that a patient with AKP has a peculiar psychological profile that might explain the pain. This belief is reinforced by many patients having very disabling pain but insignificant radiological findings and unremarkable physical signs. The psychological explanation could not be further from the truth though. Domenech *et al*.[6,7] have demonstrated that psychological factors modulate the pain, but they do not cause it. Rathleff *et al*.[8] have shown that young female adults with long-standing AKP demonstrated impaired conditioned pain modulation. This is, AKP might have important central components that need to be studied in order to understand its extent and therapeutic implications. Another misconception is that AKP is a self-limiting and benign condition, which is why some physicians recommend "expectation" measures. That approach is a great mistake. Collins *et al*.[2] have demonstrated that the success of the therapy depends on how recently the pain began. Rathleft *et al*.[9] reported that AKP is not a self-limiting knee condition. Further, AKP in an adolescent has a high potential for becoming chronic. Conchie *et al*.[10] brought into question the traditional belief that AKP in adolescence is a benign pathology, by showing that

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it is associated with patellofemoral osteoarthritis in adulthood. That is, AKP and patellofemoral osteoarthritis may form a continuum of disease. Therefore, we must take this pathology seriously.

In addition, to make the black legend of this pathology even bigger, we must point out that it is a source of iatrogenia[11]. We must be very cautious when recommending surgical treatment in AKP patients. This caution is particularly directed to those "well-meaning trigger-happy orthopaedic surgeons" educated in a purely structural/anatomical/biomechanical view of this pathology. These surgeons operate on what magnetic resonance imaging (MRI) shows. This approach is a blunder—the patient who began with just mild, intermittent symptoms becomes even worse. The same condemnation applies to inappropriately aggressive physical therapy. We must beware of structural anomalies. In fact, only a poor correlation exists between structural anomalies (chondropathy, patellar tilt and patellar subluxation) and AKP. We must avoid inappropriate or incorrect malalignment-oriented patellofemoral surgery. In agreement with Dye[12], I believe that the loss of both osseous and soft tissue homeostasis is much more important in the genesis of AKP than structural alterations (Paradigm of Tissue/Joint Homeostasis).

Unluckily, the criteria for proper treatment of the AKP patient have largely been based on individual experience. The malalignment theory strongly supported by many orthopaedics surgeons, with an almost religious fervor, has enormously damaged many AKP patients and has given this pathology a bad reputation. We need to refine the indications for AKP management and surgery, and for this refinement to happen, more studies with a high level of evidence are needed. We should not be distracted by structural findings manifested on an MRI. In this way van der Heijden *et al*.[13] have shown that structural abnormalities of the patellofemoral joint have on MRI are not associated with AKP.

We should instead treat symptoms and the patient as a whole. All pieces of the puzzle must fit. If the MRI says "small tear of the medial meniscus", but the patient's pain is in the patellofemoral joint, then the structural finding on the MRI is likely not the cause of the pain, and it not should be used to justify an arthroscopy.

In most cases an AKP patient should be treated non-surgically. Physical therapy must include the entire lower limb, with particular attention to the hip musculature[4]. Very often a patient's knee has suffered a loading event that has diminished the functional envelope of function[12] in such a way that daily activities are beyond it. I must admit that in some cases it is hard to restrict activity below the new envelope of function. It is like asking a mechanic to complete an overhaul on the transmission of a car while driving it around town. But the worst part of unrestricted activity is that it obscures the underlying problem, that is the decrease of the functional envelope of function, and can lead to inappropriate surgery; that is, surgery that makes things worse.

The preceding text reveals why many orthopedic surgeons have an aversion towards treating the AKP patient. These patients are quickly sent (by other colleagues) to the orthopedic surgeon who excels at treating this kind of pathology, although he or she is distant from the patient who experiences it. Surgeons appear to be put off by these patients even before studying their cases. However, in my eyes, AKP is one of the most intriguing pathologies from a clinical point of view because it obliges us to "think out of the box", to look deeper into the anatomy, biomechanics, biology, anatomic pathology, physiopathology and psychology.

Many years ago a good friend of mine from the United States told me that to stand out in something I had to focus on a topic that was not well-known and that many did not like. Twenty years ago, AKP fulfilled both and continues to do so. It is currently not a well-known clinical entity and, moreover, orthopaedic surgeons do not usually like to treat it. Paraphrasing the great American poet Robert Frost[14] in his poem "The Road Not Taken", I took the least travel road 20 years ago; that is, I focused on the patella. As in his poem, it made all the difference. Without a doubt, I do not regret having chosen this road.

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Acute glycemic outcomes along the aerobic training in deep water in patients with type 2 diabetes

Rodrigo Sudatti Delevatti[1,2], Nathalie de Souza Netto[1], Ana Carolina Kanitz[1,3], Cristine Lima Alberton[4], Carolina Dertzbocher Feil Pinho[1], Elisa Corrêa Marson[1], Luciana Peruchena Bregagnol[1], Salime Chedid Lisboa[1], Luiz Fernando Martins Kruel[1]

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Received: 15.07.2015
Accepted: 30.09.2015

Summary

Aims: The present study aimed to analyze the acute glucose responses in the first and last sessions of four mesocycles along an aquatic aerobic training periodization.
Methods: Fourteen patients (6 men and 8 women; 54.3 ± 9.0 years; body mass index of 34.5 ± 3.9 kg/m^2) with type 2 diabetes underwent a 12-week training program involving deep-water running. This exercise training was performed by an interval training method, with a frequency of 3 times a week, session duration of 35 minutes and intensity progressing from 85 to 90% to 95 to 100% of the anaerobic threshold heart rate (ATHR) along the periodization. Capillary glucose was assessed before and immediately after the first and last session of each mesocycle. A generalized estimated equation (time x session x mesocycle) was used to assess reductions in glucose levels in different sessions (first and last) along four mesocycles (α = 0.05).
Results: All sessions resulted in a reduction in glucose levels (time effect: p <0.001), without differences between the first and last session of each mesocycle (session effect: p = 0.738). With regard to the mesocycles (mesocycle effect: p = 0.003), significant differences were found between mesocycles 2 and 3. In time*mesocycle interaction (p = 0.002), in most comparisons, post-session values were lowest that pre-session values, regardless of mesocycle, except for the post-session value of mesocycle 3, which was similar to the pre-values of mesocycles 2 and 4.
Conclusion: Aerobic training in deep water with crescent linear periodization over 12 weeks is able to reduce glucose levels in patients with type 2 diabetes.

Key words:
Aquatic environment.
Exercise.
Diabetes Mellitus.
Glycemia.

Respuestas de la glucemia aguda a lo largo del entrenamiento aeróbico en aguas profundas en pacientes con diabetes tipo 2

Resumen

Objetivo: Analizar las respuestas de glucemia aguda en las primeras y últimas sesiones de cuatro mesociclos a lo largo de una periodización de entrenamiento aeróbico acuático.
Métodos: Catorce pacientes (6 hombres y 8 mujeres; 54,3±9,0 años; índice de masa corporal de 34,5±3,9 kg/m^2) con diabetes tipo 2 fueron sometidos a un programa de entrenamiento de 12 semanas de carrera en aguas profundas. Se realizó un entrenamiento aeróbico de intervalos, realizado 3 veces por semana, con sesiones de 35 minutos y la intensidad progresando a lo largo de la periodización desde 85% - 90% a 95% - 100% de la frecuencia cardiaca del umbral anaeróbico (FCUA). La glucosa capilar fue evaluada antes e inmediatamente después de la primera y la última sesión de cada mesociclo. Se utilizó una ecuación generalizada estimada (tiempo x sesión x mesociclo) para evaluar las reducciones en los niveles de glucosa en las diferentes sesiones (primera y última) a lo largo de cuatro mesociclos (α = 0.05).
Resultados: todas las sesiones resultaran en una reducción en los niveles de glucosa (efecto tiempo: p<0,001), sin diferencias entre la primera y la última sesión de cada mesociclo (efecto de sesión: p = 0,738). Con respecto a los mesociclos (efecto mesociclo: p=0,003) se encontraron diferencias significativas entre los mesociclos 2 y 3. En la interacción tiempo*mesociclo (p=0,002), en la mayoría de las comparaciones, los valores post-sesión fueron menores de los valores pre-sesión, independientemente de mesociclo, excepto para el valor después de la sesión del mesociclo 3, que fue similar a los valores antes de la sesión de los mesociclos 2 y 4.
Conclusión: Doce semanas de entrenamiento aeróbico en aguas profundas con la periodización linear y creciente es capaz de reducir los niveles de glucosa en pacientes con diabetes tipo 2.

Palabras clave:
Ambiente acuático.
Ejercicio.
Diabetes Mellitus.
Glucemia.

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Introduction

Type 2 diabetes mellitus (T2DM) is a worldwide public health problem predominantly resulting from obesity and a sedentary lifestyle. Interventions ensuring lifestyle changes have been effective both in the prevention and control of the disease, with exercise being one of the most effective nonpharmacological treatments for T2DM[1,2], through its beneficial effects on outcomes such as blood pressure, lipid profile and glucose levels[3].

According to the American Diabetes Association (ADA), patients with T2DM should do 150 minutes or more of aerobic exercise at moderate intensity per week, and when without complications must combine this with two or three sessions per week of resistance training[4]. These guidelines demonstrate how important aerobic training is to this population, and it is generally recommended to all patients. However, despite a lot of evidence indicating the beneficial chronic effects, especially in glucose control in this population[5-7], less is known about the acute glycemic effects of aerobic training during progressive training. Studies investigating this issue focused predominantly on the comparison between the effects of different exercise sessions in a specific training status[8-10]. To the best of the authors' knowledge, no study has investigated these effects at different times during a periodization, in which the intensity and/or duration increases along the training while the patients improve their physical fitness and metabolic status.

With regard to the periodization of aerobic training, it is worth noting that patients with a type 2 diabetes clinical profile, usually obese or overweight, can complicate increases in exercise dosage, especially in intensity, because in greater intensity for glucose control, such as those near of anaerobic threshold[11], patients are more susceptible to lower limb injury. An alternative to the necessary training progression is the training conducted in water, such as water aerobics, because the buoyancy provides attenuated impact forces, especially for the lower limbs[12]. Moreover, deep-water running is another interesting modality for the progression of exercise training because the practitioners perform aerobic exercise at high loads with reduced risk of injury, since a float vest is used to keep the body in an upright position, preventing contact between the feet and the bottom of the pool[13].

Because of its characteristics, deep-water running is favorable to progress in training without increasing the impact on joints, thereby enabling patients to exercise at high intensity or for long duration, optimizing glucose control. In addition, this modality has demonstrated a similar increase in strength to combined training in water[14] and has glycemic metabolism benefits in glucose-intolerant women[15]. The fact that this modality allows progression in training intensity, including for patients with difficulties in supporting their own body mass[16], indicates the need for knowledge about the acute glycemic effect in different stages of a linearly increasing periodization, because although it seems a great alternative, literature about "exercise and type 2 diabetes" is scarce on studies in water. Thus, the present study aimed to analyze acute glycemic responses in the first and last sessions in four mesocycles of a deep-water running program. Our hypothesis is that in mesocycles of three weeks, the acute glycemic effect not is attenuated, being similar in the first and last session of each mesocycle.

Materials and methods

Subjects

The sample consisted of 14 patients with T2DM (6 men and 8 women) who had not undertaken any physical exercise in the previous three months and were receiving their usual medical treatment. Patients with the following conditions were excluded from the sample: uncontrolled hypertension, autonomic neuropathy, severe peripheral neuropathy, proliferative diabetic retinopathy, severe nonproliferative diabetic retinopathy, decompensated heart failure, limb amputations, chronic renal failure (MDRD-GFR < 30 ml/min)[17] or any muscle or joint impairments that prevented individuals from engaging in physical exercise. The presence of these conditions was confirmed by medical history as well as clinical and laboratory examinations. All patients had undergone effort electrocardiograms in the six months preceding the study.

Research design

Patients were identified from the records of the Endocrine Division of a tertiary hospital and were also recruited through advertisements in local newspapers between June and July 2012. All participants were fully informed of the procedures involved in the study, and provided written consent prior to participation. The study was approved by the Research Ethics Committees of the Universidade Federal do Rio Grande do Sul (protocol number 108.997) and of the Hospital de Clínicas de Porto Alegre (protocol number 54475). The research design, with intervention and evaluations performed are illustrated in the Figure 1.

Anthropometric measurements

Prior to the intervention, patients underwent anthropometric measurements. Body mass and height were assessed using a digital scale and a stadiometer (FILIZOLA; Sao Paulo, Brazil). These values were used to calculate patient body mass index (BMI) using the following formula: mass (kg)/height^2 (m). Waist circumference was measured at the midpoint between the iliac crest and the last rib. Additionally, skinfolds were measured at the following eight sites: tricipital, subscapular, suprailiac, abdominal, chest, midaxillary, thigh and leg. The equations proposed by Petroski[18] were used to estimate the body density of men and women, while body fat percentages were estimated using the Siri formula[19].

Blood analysis

Blood samples (4ml) were obtained from an antecubital vein after fasting for 12 to 14 h. The samples were collected in tubes with EDTA and kept frozen at -80 ºC as total blood (without centrifugation). After blood data collection, the levels of HbA1c were determined through high-performance liquid chromatography (HPLC) to characterize the glycemic control of the patients.

Capillary glycemia

Capillary glycemia was assessed before and immediately after the first and last sessions of each training mesocycle using a clinical glucometer (Accu-Check Performa, Roche, São Paulo, Brazil), which assesses glycemic levels in approximately 5 seconds, and a lancet device (Accu-ChekMulticlix, Sao Paulo, Brazil).

Intervention

Patients underwent 12-week training program involving deep-water running with a life vest. The interval-training program consisted of four mesocycles of three weeks each. Training was conducted three times per week (Monday, Wednesday and Friday), and each 45-minute session was divided into a warm-up period (5 min), followed by the main training program (35 min) and a cool-down section (5 min). The intensity of the physical exercise prescribed was adjusted according to each subject's heart rate deflection point (HRDP), which was determined by a progressive maximal test conducted in the water environment. This method was chosen due to its ease of application and association with the second ventilatory threshold, a precise indicator of the relative stress caused by exercise[20]. Participants were asked to wear HR monitors (RSX 300, Polar) during the exercise sessions to control training intensity. Each individual was asked to read and report their heart rates to one of the three instructors who supervised the exercise sessions. Each instructor then used a table containing subjects' training heart rate ranges to provide feedback on the recommended exercise intensity for each patient. The 12-week training program prescribed to each participant is described in Table 1.

Statistical analysis

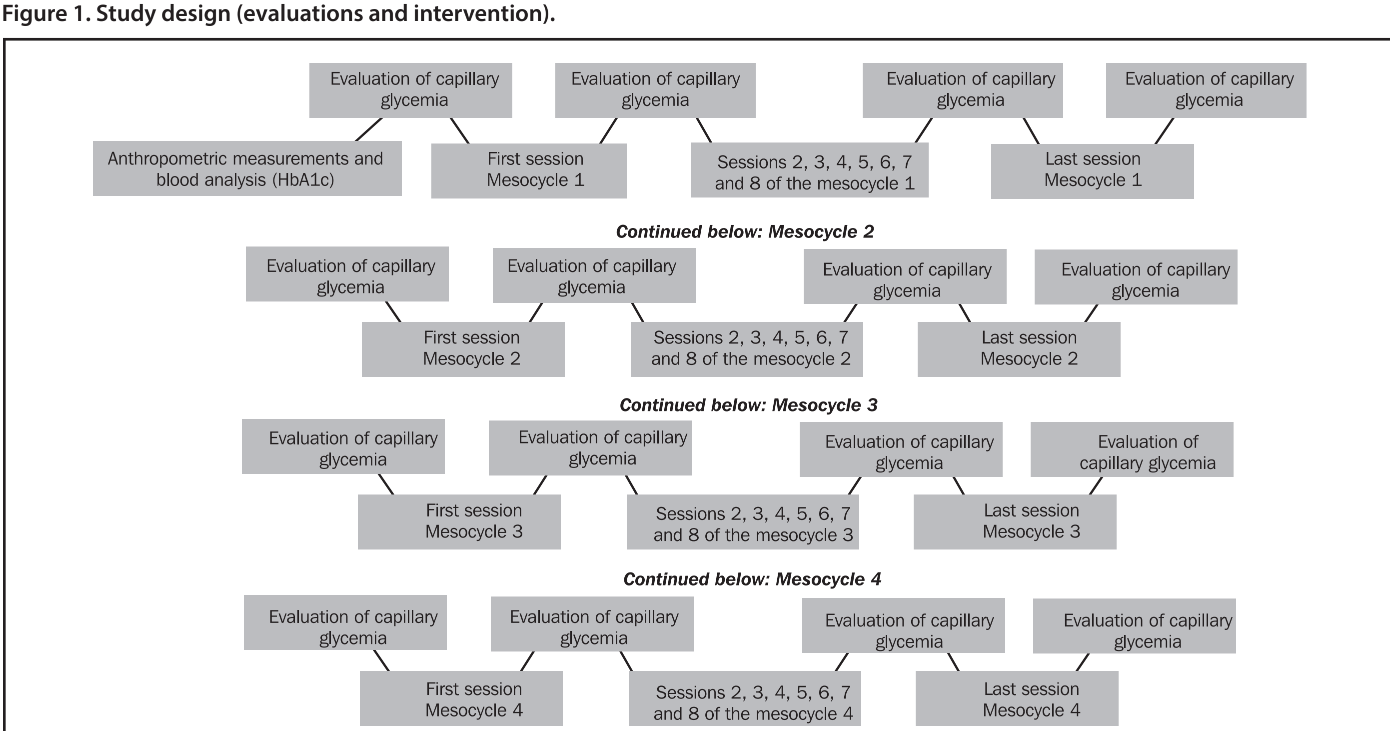
Descriptive data of the subject characteristics are presented as mean and standard deviation for continuous variables and as n for categorical variables. Glycemic levels are presented as mean and standard error. A generalized estimation equation (GEE) was used to assess alterations in glucose levels (pre versus post) in different sessions (first and last) in each mesocycle of training, taking into consideration the three factors involved in the analysis (time, session and mesocycle). Given that exogenous insulin use could potentiate an exercise glucose-lowering effect, we performed the analyses for all patients, and excluding those patients using insulin. Multiple comparisons were performed with Bonferroni correction. The level of significance was set at $\alpha = 0.05$. All analyses were performed using the Statistical Package for the Social Sciences (SPSS) software, version 19.0.

Table 1. 12-week aerobic training program.

Mesocycle	Week	Training sessions	Duration (main part)
1	1 - 3	7x (3 min 85-90% ATHR with 2min <85% ATHR)	35 min
2	4 - 6	7x (4 min 85-90% ATHR with 1min <85% ATHR)	35 min
3	7 - 9	7x (4 min 90-95% ATHR with 1min <85% ATHR)	35 min
4	10 - 12	7x (4 min 95-100% ATHR with 1min <85% ATHR)	35 min

Note: ATHR: Anaerobic threshold heart rate.

Figure 1. Study design (evaluations and intervention).



Results

Sample data regarding disease duration, age, anthropometric measurements and medication use are shown in Table 2.

Table 2. Subject characteristics.

Age (years)	54.3 ± 2.4
Duration of DM2 (years)	5.4 ± 1.0
HbA1c (%)	7.9 ± 0.7
Body mass (kg)	93.1 ± 3.6
Body mass index (kg.m^{-2})	34.5 ± 1.0
Waist circumference (cm)	111.7 ± 2.9
WHR	0.68 ± 0.02
Fat mass (%)	37.5 ± 1.1
Sex (male/female)	6/8
Medical treatment	
Metformin (n)	12
Sulphonylurea (n)	6
DPP-4-inhibitors (n)	1
Pioglitazone (n)	1
Diuretics (n)	4
Beta blockers (n)	4
ARAs II (n)	4
Acetyl-acetylsalicylic (n)	5
Statins (n)	7
Insulin (n)	3

DPP-4: dipeptidyl peptidase-4; ARAs: Angiotensin receptors antagonists; WHR: waist/height ratio; Values of age, duration of DM2 and anthropometric measures are expressed as the mean ± SE; Values of sex and medication are expressed by *n*.

All training sessions determined a reduction in glucose levels (time effect: p <0.001). In all mesocycles, the first session values did not differ from the values found in the last session (session 1 = session 9, session 10 = session 18, session 19 = session 27, session 28 = session 36; session effect: p = 0.738). Between the mesocycles (mesocycle effect: p = 0.003), significant differences were found only between the pre-session values of mesocycles 2 and 3 (Table 3). In time*mesocycle interaction (p = 0.002), significant differences were found between pre-session and post-session values in most comparisons, except for the post-session value of mesocycle 3, which was similar to the pre-values of mesocycles 2 and 4.

Given that exogenous insulin use could potentiate an exercise glucose-lowering effect, we performed an analysis excluding those patients using insulin. The results, however, were very similar: Exercise sessions determined reductions in glucose levels (time effect: p < 0.001), without differences between the first and last session of each mesocycle (session effect: p = 0.889). Between the mesocycles (mesocycle effect: p = 0.018), significant differences were found only between the pre-session values of mesocycles 2 and 3 (Table 4). In time*mesocycle interaction (p = 0.012), significant differences were found between pre-session and post-session values in most comparisons, except for the post-session value of mesocycle 1, which was similar to the pre-value of mesocycle 2.

No hypoglycemic episodes or other adverse effects were reported over the course of the study.

Discussion

This study showed that acute exercise sessions performed in an aquatic environment are effective in reducing glycemia. The mesocycle composition of three weeks was enough to maintain the glucose mag-

Table 3. Glucose levels pre and post exercise sessions along the four mesocycles during a deep-water running periodization in all patients (n=14).

	First session			Last session		
	Pre session	Post session	Mean difference	Pre session	Post session	Mean difference
Mesocycle 1	171.3 ± 20.5	138.7 ± 11.8*	-32.6	174.0 ± 22.5	137.9 ± 17.2*	-36.1
Mesocycle 2	163.2 ± 19.6[a]	131.2 ± 16.2*	-32.0	164.7 ± 22.0[a]	144.6 ± 19.7*	-20.1
Mesocycle 3	208.6 ± 28.1[b]	140.7 ± 18.5*[a]	-67.9	192.4 ± 27.4[b]	150.7 ± 24.3*[a]	-41.7
Mesocycle 4	168.8 ± 18.6[a]	130.2 ± 16.3*	-38.6	169.8 ± 19.3[a]	141.0 ± 15.3*	-28.8

Data are reported as mean and standard error; *indicates significant difference between pre *vs.* post session values; Different letters indicate significant difference between pre values of mesocycles 2 and 3; Same letters indicate that pre-session values of mesocycle 2 are similar to post-session values of mesocycle 3; Generalized estimated equation; Bonferroni correction.

Table 4. Glucose levels before and after the exercise sessions in the four mesocycles of deep-water running in patients excluding those using insulin (n=11).

	First session			Last session		
	Before session	After session	Mean difference	Before session	After session	Mean difference
Mesocycle 1	146.8 ± 19.2	118.0 ± 5.7*[a]	-28.8	135.2 ± 10.8	106.2 ± 7.4*[a]	-29.0
Mesocycle 2	128.8 ± 8.5[a]	102.3 ± 5.2*	-26.5	131.6 ± 12.1[a]	115.7 ± 7.5*	-15.9
Mesocycle 3	165.0 ± 21.9[b]	109.10 ± 11.0*	-55.9	145.0 ± 14.4[b]	112.8 ± 12.4*	-32.2
Mesocycle 4	134.9 ± 7.5	100.1 ± 6.6*	-34.8	135.5 ± 10.0	117.0 ± 8.2*	-18.5

Data are reported as mean and standard error. *indicates significant difference between pre *vs.* post session values; Different letters indicate significant difference between pre values of mesocycles 2 and 3; Same letters indicate that post-session values of mesocycle 1 are similar to pre-session values of mesocycle 2; Generalized estimated equation; Bonferroni correction.

nitude reduction during the mesocycles, without deteriorating effects as the patients adapted to the session model. The increasing intensity between the four different mesocycles was able to continue to impact glucose levels beneficially during the 12 weeks, underlining the similarity of post-exercise values in the third mesocycle to pre-exercise values in the fourth mesocycle, indicating a possible training adaptation.

Glucose reduction after training sessions has been the target of many investigations[8-10]. However, the aim of these studies is usually to compare the acute glycemic effects of different modalities. In this context, aerobic training has shown a greater glucose reduction than resistance training[10] and a similar glucose reduction to combined training with a similar duration (40 min)[9]. Bachi *et al*.[10] reported an area under the curve of glucose during 60 min of aerobic exercise lower than that observed during 60 min with no exercise. Figueira *et al*.[9] found a glucose reduction of approximately 16% after sessions in both aerobic and combined training, a reduction that was sustained for only three hours after the end of the sessions. However, these investigations are restricted to land, which creates difficulties in performing exercise for some patients, because the disease is usually associated with obesity[21,22], sarcopenia[23], muscle weakness[24] and chronic complications characteristic of the disease, such as peripheral neuropathy[25] which end up limiting this population's adherence to exercise programs. These patients' clinical profile emphasizes the importance of our findings, because we found an expressive glucose reduction (average of the eight evaluated sessions: 34 ± 14 mg/dl; 19 ± 6%) without joint impact, something that is extremely important, especially because in addition to glycemic disorder, patients were obese and many had pain and a history of musculoskeletal injury.

One thing in common among studies analyzing glucose reduction with exercise is that they compared the effect of different training modalities or different manipulations of the same modality in a given state of trainability (sedentary or trained). However, it is necessary to elucidate possible physiological adaptations caused by aerobic training, which can attenuate glucose reduction in a given dosage of exercise, needing an adequate progression in the variables of the training for continuity of this desirable effect. Among aerobic training adaptations, we find the improvement in muscle oxidative capacity, the increase in fatty acid oxidation[26], and in the expression and activity of signaling enzymes and proteins, important for glucose metabolism, like glycogen synthase and GLUT 4[27]. This leads to a greater use of lipid pathways at the same relative intensity and a greater storage of muscle glycogen, which sometimes is 50% smaller in patients with T2DM than in nondiabetic ones[28]. Thus, trained patients will be able to have a greater glucose supply derived from muscle storage during exercise, because skeletal muscle is the major site of available glucose in human[29], with the same input of blood glucose not being necessary for a given activity compared to a sedentary situation, with low muscle glycogen storage. Because of these alterations, we believe that, in order for an expressive acute effect on glucose levels to continue to exist, it is necessary to have periodic increases in the dosage of the exercise (i.e. intensity). Although the adaptations to training referred to have been well demonstrated, the glucose effects of a same session model in different stages of a periodization have not been compared. With this proposal, we didn't find differences between the first and the last sessions of each mesocycle, which demonstrated that up to three weeks, the adopted prescription in the present study enables acute glucose reduction through all mesocycles.

When comparing the different mesocycles, the importance of progression, either by changes in relationship stimulus: recovery (mesocycle 1 for mesocycle 2), or in stimulus of intensity (mesocycle 2 for mesocycle 3; mesocycle 3 for mesocycle 4) was also evidenced by the present findings. When analyzing the differences we found, it is noticeable that there was no attenuation in glycemic responses, something expected if the exercise dosage is not increased adequately. The fact that all sessions resulted in glucose reductions showed that the increases were efficient in terms of progression during the mesocycles. It is possibly for the fixed duration (35 min) and increases in intensity, which leads to increased volume and intensity, the main components of physical training. The association between training progression and reduced capillary glucose has not been sufficiently studied in patients with type 2 diabetes, which prevents comparisons between the present findings and those of other studies. Calculating an mean of the eight deltas in the present study, the reduction found (34 ± 14 mg/dl) was similar to the findings of Terada *et al*.[8], in which a similar sample underwent a 12-week land-based aerobic training program, and it was found that participant glucose levels decreased by a mean of 34.2 ± 30.6 mg/dl. In the study in question, however, only exercise volume was increased, by increasing the duration over the course of the intervention, maintaining a mean intensity of 40% of oxygen uptake reserve over the mesocycles. Analyzing simultaneously this progression of training and the one used in the present study, we have two models that focus on different variables, but with a similar magnitude of glycemic reduction. While Terada *et al*.[8] adopted a progression focused on the duration of the training sessions, the present study adopted a progression based especially on intensity. Both strategies of periodization seem appropriate, and can be used as needed. The different progressions can be adapted to the profile of patients: While subjects with limitations for training at high intensity (i.e. land-based exercise, leading to higher joint impact) can progress in training duration, subjects with little available time for training may fix the duration of sessions and increase the intensity.

Another important issue to discuss is the effect of using or not exogenous insulin on glycemic responses and the possibility of exercise causing hypoglycemia. In a study[30] analyzing the effect of a single session of aerobic exercise performed on a cycle ergometer, with moderate intensity (35-50% of maximal power), a similar glycemic reduction effect was shown between insulin users and nonusers, differing only with respect to glycemic variability and the prevalence of hypoglycemia, which was higher in the insulin users. In the present study, an analysis without exogenous insulin users showed minimal differences in relation to the overall analysis, these being the differences between the post-exercise values of the third mesocycle and the pre-exercise values of the fourth mesocycle, besides the similarity between the post-exercise values of the first mesocycle and the pre-exercise values of the second mesocycle, which was not demonstrated in the overall analysis. These small differences do not modify the posterior analysis, because the training periodization adopted allowed glucose reductions throughout its course (all patients or without insulin users).

In conclusion, deep-water aerobic training with an increasing linear periodization, especially progressive in intensity every three weeks, is able to reduce glucose levels in patients with type 2 diabetes over 12 weeks – important information for structuring training aimed at controlling the glucose levels in this population. These findings suggest the need for further studies investigating glycemic behavior at the beginning and end of training cycles with different durations (>3 weeks), aimed at widening knowledge of the influence of different training adaptations on the effects of acute exercise on blood glucose levels.

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Effect of strength training on body composition, strength and aerobic capacity of Brazilians adolescents' handball players related with peak growth rate

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Received: 16.03.2015
Accepted: 01.10.2015

Summary

Objective: During adolescence are expected significant increases in growth rate, strength and body proportions. The purpose of this study was to examine changes in strength, body composition and aerobic capacity after a strength training during different peak growth rate periods in adolescent handball players.
Material and method: Twenty-five male adolescents' handball players performed a strength-training program for 8 weeks. The body fat percentage was estimated by Slaughter equation, and the Peak Growth Rate (PGR) defined as: 1= before peak, 2= within peak; 3= after peak. The repetition maximal test (1RM) was performance for upper (bench press) and lower-body strength (leg press). Analyze of variance and post-hoc was computed to determine differences between PGR groups, strength and aerobic capacity.
Results: No significant changes in body composition were found following after the strength-training program. Upper-body strength increased (Δ = 26.3%) in the PGR 1 significantly compared to PGR 3 (Δ = 13.4%) ($p < 0.05$). No significant changes were found between the PGR groups 1, 2 and 3 on aerobic capacity (Δ = 2.9%, 3.4% and 3.8%, respectively) and lower-body strength raise (Δ = 11.3%, 19.0% and 15.2%, respectively) after training program in all groups.
Conclusions: Changes in body composition were observed between PGR. Aerobic capacity and strength do not differ between limbs at early and average PGR. Increased VO2max, upper and lower-body strength was found in late PGR group in handball players following 8 weeks of strength training.

Key words:
Exercise.
Body composition.
Strength training.
Adolescent.

Efecto del entrenamiento de la fuerza sobre la composición corporal, fuerza y capacidad aeróbica de los jugadores adolescentes de balonmano brasileños relacionados con el pico de crecimiento

Resumen

Objetivo: Durante la adolescencia se esperan aumentos significativos en la tasa de crecimiento, la fuerza y proporciones corporales. El propósito de este estudio fue examinar los cambios en la fuerza, la composición corporal y la capacidad aeróbica posteriores a un programa de entrenamiento de la fuerza durante diferentes períodos de la tasa de crecimiento pico en jugadores de balonmano adolescentes.
Material y método: Veinticinco adolescentes, jugadores de balonmano masculinos, realizaron un programa de entrenamiento de fuerza durante 8 semanas. Se calculó el porcentaje de grasa corporal por la ecuación de Slaughter y la tasa de crecimiento pico (TCP) se definió como: 1 = pre-pico, 2= pico y 3 = post-pico. Se realizó la prueba de una repetición máxima (1RM) en los miembros superiores (press de banca) e inferiores (*press* de piernas). Se usaron pruebas de análisis de varianza (ANOVA) y los respectivos post hoc para determinar las diferencias entre los grupos de TCP para las variables de fuerza y capacidad aeróbica.
Resultados: No hubo cambios significativos en la composición corporal después del programa de entrenamiento. La fuerza en los miembros superiores aumentó (Δ% = 26.3) significativamente en el grupo de TCP1 en comparación con el grupo TCP3 (Δ% = 13,4) ($p < 0,05$). No hubo cambios significativos entre los grupos de TCP1, 2 y 3 en la capacidad aeróbica (Δ% = 2,9, 3,4 y 3,8, respectivamente) ni en la fuerza de las extremidades inferiores (Δ% = 11,3, 19,0 and 15,2, respectivamente) después del programa de entrenamiento.
Conclusiones: No se encontraron cambios en la composición corporal y la capacidad aeróbica entre los grupos de TCP. La capacidad aeróbica y la fuerza en los miembros superiores e inferiores no fue diferente en los grupos de TCP. En el grupo de jugadores de balonmano TCP3 se encontraron aumentos en VO_2máx y en la fuerza del tren inferior después de 8 semanas de entrenamiento de la fuerza.

Palabras clave:
Ejercicio.
Composición corporal.
Entrenamiento de fuerza.
Adolescentes.

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Introduction

Scientific evidence[1,2] in children and adolescents have demonstrated the positive effects of physical activity as a stimulus for growth and development as well as in reducing health risk factors. In this period the maturational development expresses itself as a key process in the transition from childhood to adulthood and is characterized by rapid morpho-physiological changes[3]. During and after puberty significant increases in physical performance are observed; these changes are explained, in part, by biomechanical factors and muscular, neural and hormonal development[4-6].

The onset of resistance training during adolescence has been a topic of great interest and debate in the scientific community[7-10]. Several encourage the participation of adolescents in the resistance training program, provided they have proper planning and supervision of a competent professional[7-10].

Research in the last two decades have provided valuable information on the responses of a young organism to such training[11,12]. Early research[11] found that the children reported relatively similar strength gains than those for mature teens and young adults following resistance training at the onset of puberty. So strength training can induce adolescents neuromuscular adaptations resulting in significant increase in muscle strength, but with little change in their anthropometric measurements[13].

Resistance training is a key factor that stimulates growth, muscle hypertrophy, motor development, bone strength and increased strength[14]. In spite of this body of evidence, it has been suggested that resistance training should be done only after peak growth rate (PGR) to avoid impairing bone growth[15,16]. It is suggested that this type of training provides hormonal changes that affect the muscle strength already in prepubertal stages[17]. As a result, this type of training is being increasingly used by health professionals and adolescents.

Therefore, the purpose of this study was to examine changes in strength, body composition and aerobic power during different periods in adolescent handball players from Brazil undergo eight weeks of resistance training.

Materials and methods

Study model

This study has a quasi–experimental design with pre and post tests.

Participants

Volunteers were 25 adolescents' male handball-players, with more than one years of expertise in handball and did not have any practice strength training at least six months prior to the program, all recruited from the community of São Bento do Sul, Brazil. They were divided into three groups according to the peak growth rate in late, average, and early.

Written informed consent was obtained from parents or legal guardians and from children participating in the study according to the Ethics Committee of the Brazil (Protocol 03682812.8.40.0117).

Adolescents were allowed to participate in the study if they met the following inclusion criteria: a) males, b) adolescents, c) handball players, and d) apparently-healthy showing no sign of physical injury in the past six months. Participants were excluded from the study if: a) presented any disease throughout the period of intervention that could interfere with testing measurements, b) did not show-up to the exercise training sessions, and c) did not complete the experimental protocol.

Procedures

Anthropometric assessment. Anthropometric measurements were obtained as described in the "Anthropometric Standardization Reference Manual"[18]. Each measurement was taken three times and averaged for statistical analyses. Body height was measured to the nearest 0.1 cm using a stadiometer fixed to a wall. Individuals stood still with their heads in the Frankfort horizontal plane, barefoot, feet together, and the back surfaces of the calcaneus, pelvic, pectoral girdles and occipital regions in contact with the measuring equipment. Body mass was measured in kg on a digital platform balance, where individuals remain in light clothing, barefoot, feet positioned in the center of the platform, arms next to their bodies. The body mass index (BMI) in was calculated using the following formula: BMI = body weight in kg/body height in m^2. A protocol by was used to estimate the body fat percentage (%BF)[19]. Tricipital and subscapular skinfold sites were measured to the nearest 0.1 mm with a clinical skinfold caliper (CESCORF). Finally, measures of waist and hip circumferences[20] were also collected using a measuring tape. Then, the waist-to-hip ratio (WHR) was calculated.

Strength and aerobic power assessment. Muscle strength was assessed by the test of one-repetition maximum (1-RM) in the upper- (flat bench) and lower-limbs (leg press, 45°). The 1-RM consists in lifting the heaviest weight in a single maximum possible effort, with a full movement and without being able to repeat it again a second time[21]. The test starts with a brief warm-up with light weight below the maximum to prevent possible injuries. After a resting period of 3-min the 1-RM trial was performed. If the first attempt was successful then the following trials were preceded by a 3-min resting interval. Thus, the loads were increased until the individual failed to make a full-motion correctly. At that time was considered that the participant achieved the 1-RM.

Aerobic power was indirectly determined with a 20-m multistage run test and maximal oxygen consumption ($ml \cdot kg^{-1} \cdot min^{-1}$) was estimated according to a previously validated equation[22].

Peak growth rate assessment. The PGR measurements included height trunk, leg length, height, weight and age. The calculation of PGR followed a pattern developed in Canada[23] and validated in a Brazilian population[14]. The equation used was PGR = -9.236 + 0.0002708 (LL x TH) – 0.001663 (A x LL) + 0.007216 (A x TH) + 0.02292 (W/H), where CP: leg length, TH: trunk height-cephalic height, A: age, W: weight, and H: height. The PGR classification is as follows: a) group 1 (more that -1 year = late), b) group 2 (between -1 and + 1 year = average), and c) group 3 (more that + 1 year = early).

Exercise training program. The resistance training program was performed in the mornings four days per week. This program was divided in two blocks, "A" and "B". Following a light walk and jogging on a treadmill the participants performed the resistance training program at 75% of their previously determined 1-RM with resting intervals of 1 and 3 min between 3 sets and exercises, respectively. The 'A' block was performed on Monday and Wednesday and comprised the following exercises: a) bench press in a flat and inclined bench, b) peck deck, c) front shoulder press, d) lateral raise, e) Triceps pulley, f) leg press at 45°, g) "Smith" squats, h) leg extension, and i) rectus abdominis floor exercise. The block 'B' was performed on Tuesday and Friday and included: a) open and closes pull-ups, b) dumbbell fly, c) barbell curl and barbell biceps curl on a "Scott" bench, d) abductor and adductor leg exercises on a machine, e) calf exercises, and f) oblique abdominal exercises. All sessions always followed the same exercise order. All assessments and follow-up during the training sessions were performed by qualified trained staff from the Physical Activity Unit of the Universidad do Costestado (UnC).

Statistical analysis

All analyses were computed using the MedCalc statistical software (Ostend, Belgium). Descriptive statistics mean (M), standard deviation (±SD), frequencies and percentages were obtained. One-way analysis of variance (ANOVA) tests were used to determine differences between maturational stages and PGR periods. Tukey's post hoc were computed following significant ANOVA's F ratios. The variance equal Levene's test was applied, and when your attended assumptions adopted the parametric statistics. Statistical significance was set a priori at $\alpha \leq 0.05$.

Results

Participant's characteristics are presented in Table 1. Significant between-group differences were found on mean age, weight, height, BMI, and WHR (Table 1).

ANOVA results showed that the mean VO_2max was higher in the group 3 than in groups 1. Upper-body strength (in kg) was higher in groups 3 than in group 1 and 2 ($p < 0.05$) and upper-body strength increased in the PGR group 1 more than others ($p < 0.05$). Finally, mean lower-body strength was higher in the group 3 than in groups 1 and 2. (Table 2).

Table 1. Descriptive statistics for participants based on peak growth rate.

Variable	Peak Growth Rate			P
	Group 1 (n=7)	Group 2 (n=10)	Group 3 (n=8)	
Age (yr.)	13.5 ± 0.3	13.9 ± 0.4	14.2 ± 0.7	0.055
Body weight (kg)	38.0 ± 7.7	48.1 ± 9.0a	60.3 ± 10.7a	0.005
Body height (cm)	148 ± 2.7b	157 ± 13.7a	170.0 ± 7.3a,b	0.002
BMI (kg/m²)	18.6 ± 1.7	22.1 ± 2.3a	23.8 ± 2.3a	0.001
Body fat (%)	18.6 ± 6.2	16.8 ± 4.6	18.1 ± 4.7	0.586
WHR	0.82 ± 0.03	0.77 ± 0.03a,c	0.81 ± 0.02	0.001

Note: Group 1: late PGR; Group 2: average; Group 3: early PGR; WHR: waist to-hip ratio. $p < 0.05$, a: different from Group 1; b: different from Group 2; c: different from Group 3.

Table 2. Changes on aerobic power and strength variables after resistance training program by groups.

Variable	PGR	Pre	Post	Difference (Post – Pre)	Δ%
VO_2max (ml·kg^{-1}·min^{-1})					
	Group 1	45.6	46.9	1.3	2.9
	Group 2	48.9	50.5	1.7	3.4
	Group 3	52.1^{a}	54.1^{a}	2.0	3.8
Upper-body strength (kg)					
	Group 1	19.0	24.0	5.0	26.3^{c}
	Group 2	27.4	33.8	6.5	23.6
	Group 3	58.9^{a,b}	66.7^{a,b}	7.9	13.4
Lower-body strength (kg)					
	Group 1	57.5	64.0	6.5	11.3
	Group 2	110.4	131.4	21.0	19.0
	Group 3	174.3^{a,b}	200.7^{a,b}	26.4	15.2

Note: $p < 0.05$, a: different from Group 1; b: different from Group 2; c: different from Group 3.

Discussion

The adolescence is a stage of life where major physical and maturational changes occur. In some individuals of the same chronological age but more mature than their respective counterparts, this stage may provide advantages in terms of sports performance due to greater strength gains and increased muscle mass[24]. In this study, strength and aerobic capacity based on the PGR following a resistance training program in adolescent handball practitioners were evaluated.

Body composition (age, body weight, height, BMI, WHR), was different between groups, with a gradual increase as the adolescents advance in their growth period; however, these changes are expected and natural once groups are in a period of growth, development and maturation[25]. In the present study, we did not observe changes in body fat percentage, which remained stable during periods of PGR. This finding may be explained by the fact that teenagers were regular practitioners of handball, and regular physical activity stabilizes body fat in adolescents[26].

The peak growth rate (PGR) considers the somatic age of adolescents, an indicator frequently used in studies for practical purposes. In this study, the PGR was found at about 14 years, similar to other reports[19] and opposite to others[27], where PGR was found close to 12 years of age.

The PGR is related to other factors connected to physical fitness and motor performance. In a longitudinal study of soccer players, the PGR was achieved at an age of 13.8 yr., with a concomitant development of VO_2max and strength of upper- and lower-limbs compared to the present study[28]. However, others[14], studied the association between PGR and motor performance and found a trend towards improvement in aerobic fitness and strength following the PGR, as corroborated in the present study. Peak force development occurs at about 1 to 1.5 years after the age of PGR of body height[29], which was evidenced in the present study.

In this study there was significant upper or lower-body strength change following a training program only for group of early development (Table 2). Probably this changes can be because shortly after the PGR, there is a change in hormone profile, especially circulating testosterone, which is known to affect muscle strength development[30,31]. In muscle testosterone stimulates protein synthesis and inhibits protein degradation, combined, these effects account for the promotion of muscle hypertrophy and subsequent increase in muscle strength in response to resistance training[32]. Hormonal changes that accompany puberty contribute to a significant increase in strength depending on the increase in muscle mass[33].

One of the findings of the present study was the 26% of Δ variation at upper-body strength in late development group compared with early (Table 2). These findings reinforce the Lloyd *et al* (2009)[34] highlights that muscle power and strength can be developed at the beginning of the PGR to adulthood. Strength training can elicit significant gains in muscle strength above 10% when programs last from 4 to 19 weeks[35,36]. However, maturity has been found to be a significant predictor of such changes[36]. The training program used in the present study (i.e., 8 weeks), did not elicit a sufficient stimulus to produce significant changes in body composition and aerobic fitness in adolescents early or average, however the magnitude were different.

A study in prepubescent children[37], showed that resistance training during this stage is inefficient and does not lead to strength gains. This assertion can be justified with the pubertal growth, since it is influenced by the release of important hormones such as growth hormone (GH), insulin-like growth factor I (IGF-I), and sex steroids that induce increases in growth rate, muscle and bone maturation, functional ability and several metabolic adaptations[38]. These alterations can and will influence the physical development, capacity and performance during childhood and adolescence[6].

A limitation of this study was the small number of individuals evaluated; however, various studies reported in a meta-analysis[36] included smaller samples than in this study. Nevertheless, further research is needed to better understand the influence of PGR on strength training in adolescents.

Conclusion

Adolescents at different times of the PGR showed different body weight, height, BMI and WHR. Following 8 weeks of a resistance training program, no significant changes in VO_2max, upper-body strength and lower-body strength were observed in late and average PGR. In contrast players at after PGR show a significant change after the program for VO_2max, upper and lower strength gain. The early PGR show a significant magnitude variance in response to training sessions than late PGR.

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Fallecimiento del Dr. D. Ramon Balius i Juli

La Sociedad Española de Medicina del Deporte lamenta comunicar el fallecimiento de uno de sus miembros más queridos, el Dr. D. Ramón Balius i Juli. El Dr. Balius era Miembro de Honor de la Sociedad y hasta recientes fechas, y a pesar de su avanzada edad, gozó de una lucidez e inteligencia excepcionales para poder seguir obsequiando a los lectores de la Revista Archivos de Medicina del Deporte con su sección "Arte en el Estadio" que era un elemento caracterizador y exclusivo de la revista.

Fue uno de los padres de la Medicina del Deporte y desarrolló una excelente carrera profesional.

Lamentamos muy sentidamente su irreparable ausencia.

D.E.P.

Original article

Efficacy of motor activity in the quality of life in fibromyalgia patients: meta-analysis of clinical trials

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Received: 20.07.2015
Accepted: 13.11.2015

Summary

Introduction: Physical activity is effective in reducing fatigue, anxiety and depression in patients with fibromyalgia, and to improve the quality of life.
Objective: To evaluate the efficacy of physical activity in improving the quality of life of people with fibromyalgia, 2004-2014.
Methods: Meta-analysis of controlled clinical trials evaluating the efficacy of physical activity on the FIQ (Fibromyalgia Impact Questionnaire) and MOSSF-36 (Medical Outcome Study Short Form) scores, with 18 search strategies in four multidisciplinary databases. A protocol that containing criteria for inclusion, exclusion, assessment of methodological quality and extraction of information, were applied by two researchers to ensure reproducibility. Random effects meta-analysis, sensitivity analysis, DerSimonian-Lairds heterogeneity and publication bias with Begg test was performed.
Results: 10 studies were included, the most in Spain and Brazil; 203 patients with intervention and 238 in the control group. The meta-analysis showed homogeneity in the FIQ and MOSSF-36 scores between groups, prior to the implementation of the intervention; after the application of intervention were identified difference of 14.9 points (95% CI 10.3; 19.5) in the FIQ and 2.0 on the MOSSF-36, was best in the group that received exercise therapy.
Conclusion: The major efficacy of regular physical exercise is evident, compared with conventional treatment, to improve the quality of life of patients with fibromyalgia. Measuring the quality of life as a primary outcome in clinical trials should be performed with the FIQ.

Key words:
Fibromyalgia. Quality of fife. Health status. Motor activity. Controlled clinical trials as topic. Meta-analyses.

Eficacia del ejercicio físico sobre la calidad de vida en fibromialgia: meta-análisis de ensayos clínicos

Resumen

Introducción: La actividad física es eficaz para disminuir fatiga, ansiedad y depresión en pacientes con fibromialgia, esto redunda en un mejoramiento de su calidad de vida.
Objetivo: Evaluar la eficacia de la actividad física en el mejoramiento de la calidad de vida de personas con fibromialgia, 2004-2014.
Métodos: Meta-análisis de ensayos clínicos que evaluaron la eficacia de la actividad física sobre los puntajes del FIQ *(Fibromyalgia Impact Questionaire)* y MOSSF-36 *(Medical Outcome Study Short Form)*, con 18 estrategias de búsqueda en cinco bases de datos multidisciplinarias. Se aplicó un protocolo que, a priori, contenía criterios de inclusión, exclusión, evaluación de la calidad metodológica y extracción de la información, aplicado por dos investigadores para garantizar reproducibilidad. Se realizó meta-análisis de efectos aleatorios, análisis de sensibilidad, heterogeneidad con DerSimonian-Lairds y sesgo de publicación con estadístico de Begg.
Resultados: Se incluyeron 10 estudios, la mayoría desarrollados en España y Brasil; se aplicó la intervención a 203 pacientes y el control a 238. El meta-análisis demostró homogeneidad en los puntajes del FIQ y MOSSF-36 entre los grupos de estudio previo a la aplicación de la intervención; posterior a ella la diferencia en el FIQ fue de 14,9 puntos (IC 95% 10,3; 19,5) a favor del grupo que recibió la terapia con ejercicio físico; mientras que en los componentes del MOSSF-36 fue de 2,0.
Conclusión: se evidencia la mayor eficacia del ejercicio físico regular, en comparación con el tratamiento convencional, para mejorar la calidad de vida de pacientes con fibromialgia. La medición de la calidad de vida como desenlace primario en estudios clínicos debe realizarse con el FIQ.

Palabras clave:
Fibromialgia. Calidad de vida. Estado de salud. Actividad física. Ensayos clínicos como asunto. Meta-análisis.

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Introduction

Fibromyalgia is a chronic illness of unknown aetiology, characterised by the presence of generalised pain that may become incapacitating for the patient; it affects the patient's biological, psychological and social spheres, generating difficulties at work, sleep pattern alterations, and a reduction in the performance of everyday activities[1]. Furthermore, it is associated with fatigue, tiredness, depression, anxiety, headaches and paraesthesia in the extremities[2,3]. Its diagnosis is carried out following the criteria of the American College of Rheumatology, which include widespread pain lasting over three months, muscular-skeletal pain and pain upon palpating at least 11 of 18 painful points[2,4,5]. This illness represents a worldwide health problem due to its high prevalence, morbidity rate and high consumption of health resources[1]. Added to this, it greatly affects the patient's quality of life, including development in the workplace, home life and social sphere[5].

To improve the pain and quality of life of these patients, pharmacological and non-pharmacological treatments are undertaken; the non-pharmacological treatments include exercise programmes, relaxation, physiotherapy and psychological or psychiatric support[5]. With reference to physical activity, previous studies have revealed their efficiency in reducing the impact of the illness by improving symptoms, including low levels of fatigue, anxiety, depression, and in general an improvement to the health-related quality of life (HRQL) and the overall state of health[6-7].

The assessment of health-related quality of life in this illness has been performed using specific and generic instruments, including in particular the *Fibromyalgia Impact Questionnaire* (FIQ) and the *Medical Outcome Study Short Form* (MOSSF-36), which both enable clinical monitoring, help guide decision making for health providers, obtain clinical outcome measures and perform cost-effectiveness or cost-usefulness analyses[1,8].

In view of the aforementioned, various controlled clinical trials about the effectiveness of physical activity in improving health-related quality of life and the state of health of people with fibromyalgia have been carried out. Despite this, there are no clear conclusions, with powerful and solid statistics, which is why a systematic review must be performed to meta-analyse the evidence from previous articles and to give greater external validation to the outcomes and conclusions. With this objective, in 2008 a meta-analysis was published with controlled clinical trials that collected research carried out up to 2005[9]; however, this information requires updating, as systematic reviews on this issue have revealed that the most research has been concentrated over the past two three-year periods, meaning that it is possible that the effects of physical activity on the quality of life of fibromyalgia patients have changed over these past 6 years with the diversification of exercise programmes[8]. Added to this, this meta-analysis concentrated the results on a specific scale (FIQ), leaving aside the generic MOSSF-36 scale that may be more sensitive to clinical changes[10].

In accordance with the aforementioned, this study was designed with the aim of assessing the effectiveness of physical activity on improving the health-related quality of life and overall state of health of fibromyalgia sufferers, based on articles published between 2004 and 2014.

Material and methods

Type of study

Meta-analysis of clinical trials.

PICO: Population Intervention Comparison Outcome

Population. Patients diagnosed with Fibromyalgia according to the criteria established by the American College of Rheumatology[11].

Intervention. Physical activity for at least 3 weeks, by which physical activity is understood to mean aerobic exercise in which the heart rate is maintained at over 50% of the maximum frequency, flexibility exercises, stretching, strengthening or a mixture of these according to the *American College of Sports Medicine guidelines for exercise testing and prescription*[12].

Comparison. Patients with fibromyalgia that do not perform physical activity or that do so with less intensity than that established in the intervention. This group includes conventional education or guidance interventions about lifestyle provided by the rheumatologist; pharmacological treatment prescribed by the doctor and light physical activity such as stretching or routines that do not exceed 30 minutes per session or three days per week.

Outcome. Quality of life score obtained using the FIQ or MOS-SF36 scales, or both, for the study group as well as the control group, before and after the intervention. Note that this review was not restricted to studies that simultaneously applied both scales, given that the index generated by the FIQ is independent from the physical and mental components of the MOSSF-36, meaning that this restriction would reduce the exhaustive nature of this study.

Measuring health-related quality of life

The FIQ is a specific instrument to measure the impact of fibromyalgia in functional capacity and the quality of life of the people affected. It is composed of 10 dimensions that evaluate physical capacity, habitual work, impact on paid labour activity, pain, fatigue, feeling of tiredness, stiffness, feeling of well-being, anxiety and depression; the domains generate a score between 0 and 100, with 0 being the best result in HRQL, or the least impact caused by the fibromyalgia[13].

The MOSSF-36 is a generic HRQL questionnaire composed of 36 items that generate an 8-dimension profile: body pain, physical performance, physical function and overall health that is summarised in a physical component, emotional performance, social function, mental health and vitality that conform to the mental component. The instrument generates a score that can vary from 0 to 100 points; the higher the score, the better the HRQL, and the reference value established in a healthy population is 50±10 points[14].

Research Protocol according to PRISMA phases (Preferred Reporting Items for Systematic reviews and Meta-Analyses)[15]

Article identification or search. A sensitivity search was carried out in the literature related to quality of life in fibromyalgia from the Pubmed database, Science Direct, Lilacs and Scielo; using the following search strategies: *"Calidad de vida & Fibromialgia", "Calidad de vida relacionada con la salud & Fibromialgia", "Calidad de vida & FIQ", "Calidad de vida & SF-36", "Calidad de vida relacionada con la salud & FIQ", "Calidad de vida relacionada con la salud & SF-36"* and their counterparts in English and Portuguese. As well as this, a search was performed of clinical trials in the Cochrane Library with the terms *"physical activity in the quality of life in fibromyalgia" and "motor activity in the quality of life in fibromyalgia".*

Screening or applying the inclusion criteria

- Contain search terms in the title or abstract,
- research studies published between 2004 and September 2014,
- original articles and
- being a controlled clinical trial.

Some syntax used were:

- *(quality of life [Title/Abstract]) AND fibromyalgia [Title/Abstract];*
- *(health related quality of life[Title/Abstract]) AND fibromyalgia impact questionnaire [Title/Abstract];*
- *TITLE-ABSTR-KEY (health related quality of life) and TITLE-ABSTR-KEY (fibromyalgia impact questionnaire);*
- *pub-date > 2003 y iv) TITLE-ABSTR-KEY (quality of life) and TITLE-ABSTR-KEY (fibromyalgia).*

Selecting or applying the exclusion criteria

- Publications with interventions different to physical activity or multi-disciplinary interventions (educational, pharmacological, physiotherapeutic, psychological);
- articles with internal validation problems due to the failure to control bias or confusing variables;
- articles that do not explicitly mention the quality of life scores before and after the intervention in each of the compared groups.

To assess the methodological quality of the studies, the following criteria were applied: randomisation, concealment, calculation of the sample size, analysis by treatment intentions, safety report and homogeneity analysis. A form was made categorising the study with 1 if it contained the criteria, and with 0 for those that did not apply. With these a total was reached, taking scores equal or greater than 4 as good quality. Given that in the studies included the majority had a similar character (between 2 and 4 points), a meta-regression was not carried out for this variable.

Gathering the information

Two researchers applied the research protocol independently to ensure the ability to reproduce the review; discrepancies were resolved by consensus or through reference to a third party. The articles obtained were exported to an Endnote Web programme to eliminate duplicates. Once this stage was finished, the classification process of the studies began by carefully reading the abstracts and by creating a data extraction format stored in an Excel-designed database. Extracting the information was performed independently by two researchers with the aim of ensuring the inter-observer reproducible nature, in which the kappa coefficient of 1.00 for the year and place of study variables was obtained; and Intraclass Correlation Coefficient (CCI) of 1.0 for quality of life scores.

Analysing the information

The studies were characterised according to the place and year of performance. The standard deviation of the overall scores of each of the MOSSF-36 and FIQ dimensions was established based on the variation coefficient calculated in the individual studies.

To ensure the homogeneity of the groups, a meta-analysis was performed for average differences with the quality of life scores at the start of the study. The aforementioned was carried out given that in the studies this analysis was not performed, nor was a health-related quality of life score defined as inclusion criteria.

The efficacy of physical activity on the quality of life of fibromyalgia patients was assessed using a meta-analysis for average differences of scores after the intervention in both the treated and control group. With the aim of equalling out the direction of the FIQ and MOSSF-36 scales, the following formula was applied: "101- FIQ score".

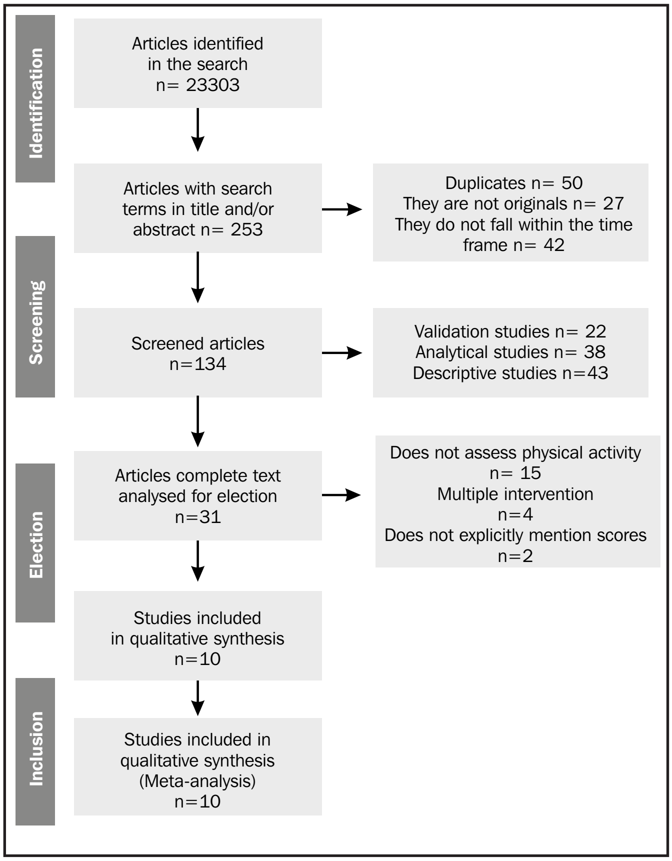
The heterogeneity was assessed with the Q statistic of the DerSimonian and Lairds test, the publication bias using the Funnel Plot, and the Begg's test statistic and a sensitivity analysis was carried out to explore the influence of each study on the size of the overall effect.

For the analyses, the Excel and Programme for Epidemiological Analysis of Tabulated Data from the Pan American Health Organisation (EPIDAT) version 3.0 was used.

Results

In the initial search, 31 articles were identified that complied with the inclusion criteria, of which 21 were eliminated for not assessing the effect of the physical activity in fibromyalgia symptoms (n=15), for using multiple treatment simultaneously, such as sociotherapy, physiotherapy, psychotherapy and art-therapy (n=4) and for not explicitly mentioning the changes in the FIQ or MOSSF-36 scores before and after the intervention (Figure 1). Based on the Cochrane search with the *"motor activity quality of life fibromyalgia, in Title, Abstract, Keywords in Trials"* strategy, six results of 893,010 articles were found that contained one or more of the search terms, and all focused on pain as the central link; with the

Figure 1. Algorithm of the article selection.



"physical activity quality of life fibromyalgia, in Title, Abstract, Keywords in Trials" strategy, 28 results were obtained, from which only two complied with the protocol and were duplicated in the findings on Pubmed.

In the studies included in the quantitative synthesis (n = 10), the majority were published between 2012 and 2014, mainly in Spain and Brazil and all included women with fibromyalgia, apart from the study by Elijk-Hustings, which included one male in the control group (n = 48). The physical intervention was performed with aerobic exercises, hydrotherapy, bio-dance and strengthening. The frequency was between 2 and 3 times a week and the total duration of the intervention was between 3 and 24 weeks. With regards to the characteristics of the people included, there was an intra-study homogeneity for the variables of age and years with the illness; however, there was inter-study variability regarding the same variable in that the average age fluctuated between 42 and 59 years. The same occurred with the average duration of the symptoms of the illness, which oscillated between 4 and 26 years (Table 1). It should be specified that the majority of the studies did not reveal other variables in the analyses of homogeneity and in the inclusion criteria the majority circumscribe to the diagnostic criteria of the illness and the type of institutions where the patients were found; this prevents further research into potential variables for a meta-regression.

All the test groups applied interventions in which they reached a minimum of 50% of their maximum heart rate, though in some studies this intensity was higher with increases between 55-64%[16], 60-85%[18], 50-69%[23] or 60-70%[25] according to ACSM recommendations.

Table 1. Description of the articles included in the quantitative synthesis.

Author	Year	Country	Group	n	Age	Years with the illness	Treatment
Eijk-Hustings[16]	2013	Netherlands	EG	19	43.9±7.6	6.2±7	Aerobic exercises
			CG	48	42.9±11	7.1 ± 6.4	Conventional treatment
Fernandes de Melo[17]	2006	Brazil	EG	24	48.9±9.2	---	Hydrotherapy
			CG	23	46.6±8.4	---	Conventional physiotherapy
García-Martínez[18]	2012	Spain	EG	12	59.3±4.8	9.9±3.8	Physical exercise
			CG	13	58.6±7.8	10.6 ±4.1	Conventional treatment
Latorre[19]	2013	Spain	EG	42	50.9±7.7	9.1 ± 3.8	Physical exercise
			CG	30	52.4±8	9.0±4.8	Conventional treatment
López-Rodríguez[20]	2012	Spain	EG	19	55.5±7.7	12.5±7.4	Aquatic bio-dance
			CG	20	55.3±7.5	14.3±8.3	*Stretching*
Martín-Nogueras[21]	2012	Spain	EG	15	52.6±8.4	4.6±3.2	Physiotherapy and aerobics
			CG	13	48.1±6.9	6.4±6	Conventional treatment
Oliveira[22]	2014	Brazil	EG	35	44.3±7.9	---	*Strengthening*
			CG	31	48.6±7.6	---	FLEX
Sañudo[23]	2007	Spain	EG	14	57.9±6.2	---	Physical exercise and vibration training
			CG	12	60.1±9.4	---	Physical exercise
Tomas-Carus[24]			EG	17	51±10	24±9	Aquatic exercise
			CG	17	51±9	27±4	Conventional treatment
Vinícius Ietieri[25]	2013	Brazil	EG	33	58.2±10.6	---	Hydro-kinesiotherapy (PSE)
			CG	31	59.6±9.4	---	Conventional treatment

Group EG: Experimental group; CG: Control group.

All the studies applied the intervention with a duration of one hour per session, with the exception of two studies which lasted 45 minutes[22,25], each session included between 5-10 minutes of warming up, 30-40 minutes of physical aerobic exercise and/or strengthening, with 5-10 minutes of stretching and relaxing. The intervention time varied with six[23], twelve[16-18,20,21], fifteen[25], 1622 or 24 weeks[19]; in half of the studies 2 sessions per week were applied[16,21,22,23,25] and in the rest, three.

Regarding the instruments to assess the effect of physical activity on the quality of life, 4 used both the FIQ and the MOSSF-36, 4 studies only applied the FIQ and 2 only applied the MOSSF-36. Before starting the intervention, the FIQ scores in the test group and the control group fluctuated between 22.5 ± 11.1 and 52.1 ± 12.1 points; the same procedure was performed after the intervention and in this case the test group scores were between 44 ± 16 and 57.2 ± 12.3 and for the control group between 22.0 ± 10 and 51.2 ± 14.9. With regards to the HRQL according to the MOSSF-36 in the physical component prior to treatment, scores were obtained between 9.7 ± 26.4 and 44.6 ±12.7; following intervention the test group displayed scores between 33.6 ± 35.8 and 75.6 ± 14.2. Mental health was also assessed before treatment in both groups with results between 38.4 ± 17.0 and 58.0 ± 16.5 points and after the intervention the scores in the treated group were between 50.1 ± 25.0 and 69.3 ± 20.9 (Table 2).

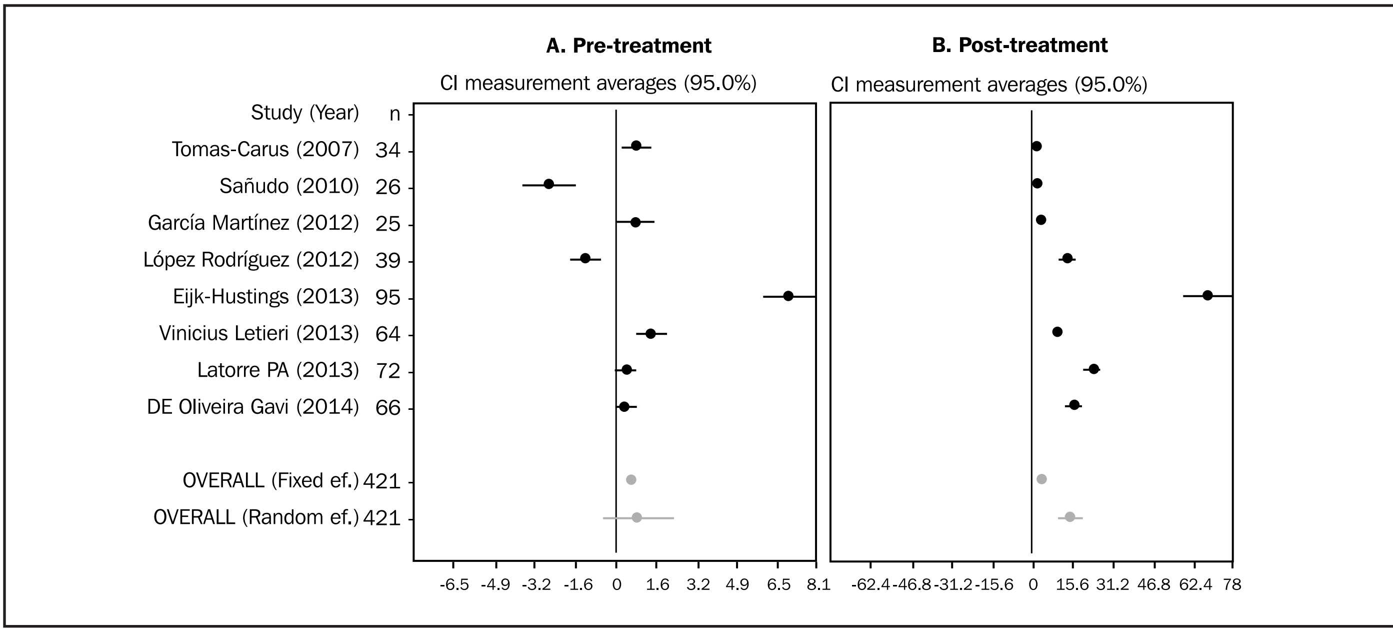
Upon performing the meta-analysis of the FIQ scores before and after the intervention, both the treated and control groups revealed heterogeneity in the studies included (Statistic Q Vp 0.000), lack of publication bias (Begg Test 0.915) and good robustness of the combined

Table 2. Description of the FIQ scores and the SF-36 pre and post treatment in the experimental and control groups.

Author	Group	FIQ score X±DS		36 Score Physical X±DS		36 Score Mental X±DS	
		Pre*	Post**	Pre*	Post**	Pre*	Post**
García-Martínez	EG	28.9±13.1	50.8±12.9	33.9±18.5	50.6±27.4	46.6±18.2	61.7±18.5
	CG	32±12.5	36.2±16.7	39.6±17.5	35.4±17.2	48.0±21.3	41.5±20.3
Latorre	EG	35.5±13.5	47.7±16.3	38.7±16.2	41.5±21.3	43.1±13.4	52.7±17.4
	CG	36.2±11.6	35.3±11.8	34±17.0	34.3±16.6	48.0±18.1	39.7±17.4
Oliveira	EG	33.2±15.4	49.9±18.4	12.1±24.5	33.6±35.8	39.0±21.5	50.1±25.0
	CG	34.2±17.2	49.9±18.4	9.7±26.4	28.2±38.6	45.9±24.5	61.0±24.5
Tomas-Carus	EG	38.0±20	44.0±16	36.0±23	48.0±21	48.0±20	62.0±27
	CG	42.0±16	41.0±17	33.0±19	37.0±17	51.0±24	50.0±20
Fernandes de Melo	EG	---	---	35.5±20.1	75.6±14.2	42.4±19.4	69.3±20.9
	CG	---	---	35.5±15.0	67.7±23.5	38.4±17.0	66.8±23.9
Martín-Nogueras	EG	---	---	39.7±13.3	55.3±12.9	52.5±15.3	62.9±20.7
	CG	---	---	44.6±12.7	40.0±14.9	58.0±16.5	54.0±23.8
Eijk-Hustings	EG	41.0±2.1	49.0±3.2	---	---	---	---
	CG	45.6±2.3	44.8±2.9	---	---	---	---
López-Rodríguez	EG	33.9±10.5	48.8±16.2	---	---	---	---
	CG	31.5±13.0	31.8±12.9	---	---	---	---
Sañudo	EG	52.1±12.1	57.2±12.3	---	---	---	---
	CG	44.1±11.6	51.2±14.9	---	---	---	---
Vinicius Letieri	EG	22.5±11.1	48.5±15.6	---	---	---	---
	CG	25.3±10.3	22.0±10	---	---	---	---

Group EG: Experimental group; CG: Control group; *Pre: Pre-treatment; **Post: Post-treatment.

Figure 2. ***Forest Plot*** **for the difference in averages of the FIQ scores in the test and control groups.**



measures, given that in the sensitivity analysis the exclusion of each of the studies did not affect the overall result. In the *Funnel Plot* of random effects, no significant differences were found in the FIQ scores before starting the intervention 0.90 (CI 95% -0.39; 0.89) between the treated and control group; on the other hand, after intervention the difference in the average FIQ score was 14.9 points (CI 95% 10.3; 19.5) in favour of the group that received the therapy with physical exercise, proving the effectiveness of the intervention (Figure 2).

In the domain of physical health of the MOSSF-36, heterogeneity in the studies was observed (Statistic Q Vp 0.0002), lack of publication bias (Begg Test Vp 0.1329), equality in the test and control group scores prior to the intervention 0.20 (CI 95% -0.36; 0.76) and difference in favour of the group with physical activity of 2.06 points (CI 95% 1.18; 2.95) following intervention.

In the domain of mental health, the heterogeneity is maintained (Statistic Q Vp 0.000), the lack of publication bias (Begg Test Vo 0.7071), equality in the test and control groups before initiating treatment 0.07 (CI 95% -0.56; 0.71) and the difference in favour of the group that received the physical therapy, in this case of 1.86 points (CI 95% 0.30; 3.40) (Figure 3).

Discussion

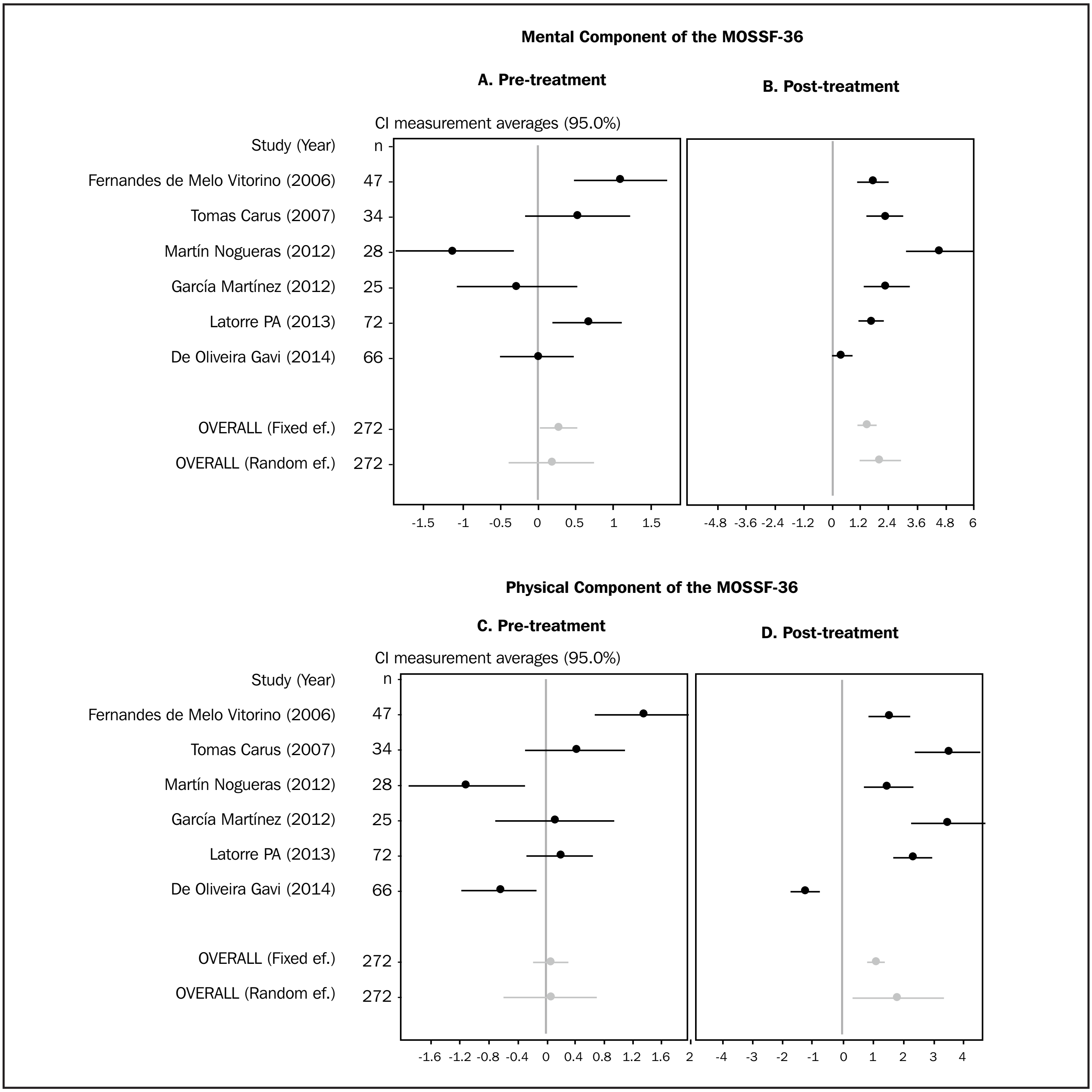
Fibromyalgia strongly affects the quality of life of sufferers, especially in the physical and mental domain. The physical alterations are revealed as chronic pain, disability to perform everyday activities and the ongoing use of medication. The psychological and mental limitations are characterised by stress, depression and anxiety. Previous studies have described the impact of the illness on the physical and mental domain on the quality of life of patients, using instruments such as the FIQ and the MOSSF-36. The latter reveals scores below 50 which is the benchmark for healthy populations[10], which is in keeping with this research in that the pretreatment scores were lower than 50 points.

Among the therapeutic options to treat the illness and reduce the impact on the patient's quality of life, performing regular physical exercise has been established as one of the main non-pharmacological strategies to control the symptoms. Despite this, there are still discrepancies regarding the muscular and physical capacity of these patients to take on an exercise programme, as well as the physiological mechanism by which these types of therapy generate a reduction in symptoms[26].

Discrepancies regarding the capacity of the patients to perform exercise arise because they can perceive a greater effort during physical activity; however, previous studies have revealed that muscular strength and resistance in patients with fibromyalgia are similar to those in healthy control subjects. Furthermore, in patients that undergo physical activity therapy, the beneficial effects are evident, such as reduced pain, increased strength, improved sleep quality, less fatigue and an improved psychological state[27].

In keeping with the above, in this study it was clear that the patients with physical activity experienced improvements to their HRQL by the end of the treatment, proven by the increase in the FIQ and MOSSF-36 scores. The FIQ scores of the treated group increased by 14.9 points whilst in the physical and mental domain of MOSSF-36 the increase was 2.06 and 1.86 respectively. The difference in the score of both treatments could be attributed to the nature of the scales, as the FIQ is a specific scale for fibromyalgia patients, making it more sensitive to detecting

Figure 3. ***Forest Plot*** **for the difference in averages of the Mental and Physical scores of the MOSSF-36 in the test and control groups.**



changes associated to the illness in aspects such as stiffness, morning tiredness, pain, depression and anxiety; on the other hand, MOSSF-36 is a generic measurement, in that its sensitivity is greater when it comes to detecting unforeseen effects of the illness via the domains of physical function, the physical role, body pain, general health, vitality, social role, emotional role and mental health[28].

In allusion to the mechanism that explains the beneficial effects of exercise in fibromyalgia patients, some studies have described a clear reduction in the levels of the systemic inflammatory markers such as the IL-8, and of stress such as the noradrenaline and extra-cellular heat shock proteins 72 kDa (eHsp72), which are usually increased in patients with the illness and its regulation would in part explain the reduction of the symptoms and the increase in the HRQL. Despite this, there is no consensus on this matter; furthermore physical activity should be regulated because acute exercise, with no physiological adaptation or training, could exacerbate, rather than improve, the systemic state of stress or inflammation in women with fibromyalgia[29].

Research studies into the effectiveness of physical activity in improving the symptoms of fibromyalgia and its impact on FIQ and MOSSF-36 scores, are summarised in this meta-analysis, and in this respect it provides useful information for orientating later studies and consolidating causal hypotheses, as it includes an exhaustive literary search, groups the results of various research studies into one sole measurement, gives a more precise estimation of the effect, and improves the statistical power by increasing the sample size[30].

It is important to highlight that the methodological quality of the articles included in the quantitative synthesis of this research were conditioned by aspects such as the calculation of the sample size, blinding, the analysis of the results with the treatment intentions and the analysis of the safety of the intervention. The analysis with treatment intentions implies including all the patients in the analysis, regardless of whether or not they received the whole treatment or if the originally established protocol was removed. Omitting this analysis influences the results, as the motives of the lack of adherence may be related to the prognostic or effectiveness of the treatment[31]. Blinding refers to the fact that the participants and researchers did not know which group received the intervention, reducing the bias in the physiological or physical response motivated by the type of intervention received. This is particularly important in studies in which the result measurements are far from objective, such as pain or quality of life. However, the majority of the patients involved in this meta-analysis could not be blinded regarding the treatment, as in general terms one group received physical therapy whilst the other did not, impeding blinding for obvious reasons[32]. Safety refers to the protection of patients faced with adverse and secondary effects of the intervention, in the studies included in this analysis, no long-term analysis was performed on the safety of physical activity; however, it is clearly better than the effects of pharmacological treatments with anti-depressives and anticonvulsants[33].

Among the limitations of this study, which at the same time constitute suggestions for later research that aims to assess the effect of physical activity on the HRQL of patients with fibromyalgia, is the diversity of physical interventions included, which highlight the need for experts in the field to unify criteria such as intensity, duration, frequency, and even the design of the exercise regime prescribed, particularly when dealing with an intervention to assess in a clinical trial. Furthermore, it should be noted that the Begg statistic provides good statistical power for meta-analyses with 75 or more studies, and moderate power for analyses with 25, meaning that in meta-analyses with few research studies the publication bias should be interpreted with caution. However, the number of studies included should not be taken categorically, as there are other parameters that affect the power of this statistic, even more importantly than the number of studies, such as the research selection criteria, the variations in the size of the effect and global effect. In addition, it should not be forgotten that this statistic is exploratory, and is performed as a formal procedure to complement the *Funnel_plot*[34].

Conclusion

This exercise highlights that practising regular physical activity is statistically better than conventional treatment in improving the quality of life of fibromyalgia patients, though the quality of the recommendation is low due to the limitations of the studies included, the variability in defining the test group and the low number of analysed research studies. However, the hypothesis is consolidated regarding the benefits of physical activity on this illness, as a base for the design of posterior random controlled clinical trials, and it is recommended that the measurement of quality of life as a primary outcome in clinical studies should be performed with the FIQ.

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Sedentary lifestyle level in nine cities of Colombia: cluster analysis

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Received: 11.06.2015
Accepted: 16.11.2015

Summary

Objective: To set the level of sedentary lifestyle in the population between 18 and 60 years of age in nine cities of Colombia.
Materials and methods: Descriptive correlational study with multivariate analysis. The sample was collected with 4,383 people between 18 and 60 years of age in the cities of Manizales, Pereira, Monteria, Armenia, Sincelejo, Medellin, Bogotá, Neiva and Tunja. Sample selection technique: Probabilistic and K systematic. The sedentary lifestyle test by Perez-Rojas was applied. Variables analyzed: genre, age, marital status, schooling, BMI and physical activity.
Results: From the total sample, 53.4% were men with an average age of 35.5 ± 12.9, 57.2% with High School and/or university studies and their average BMI was 24.5 Kg/m^2 ± 3.9 Kg/m^2;. The dendrogram showed two groups: active and sedentary. From the active group, 73% lived in Popayan, Bogotá, Medellin, Sincelejo and Armenia, they were between 18 and 24 years of age, men were predominant with normal BMI who exercised between 30 and 60 minutes three times per week. The sedentary groups was 27% of the population from the cities of Pereira, Neiva and Manizales, 35 years and older, predominantly women, single who did not practice any physical activity and were overweight.
Conclusions: A sedentary lifestyle is a widespread problem in the nine cities studied. Two groups were established and in the sedentary group female over 35, overweight and not being physically active stand.

Key words:
Motion. Adult. Body mass index. Sedentary lifestyle.

El nivel de sedentarismo en nueve ciudades colombianas: análisis de clúster

Resumen

Objetivo: Establecer el nivel de Sedentarismo en la población, de 18 y 60 años de edad, de nueve ciudades de Colombia.
Materiales y métodos: Estudio descriptivo – correlacional con análisis multivariado. Muestra 4.383 personas de 18 a 60 años de las ciudades de Manizales, Pereira, Montería, Armenia, Sincelejo, Medellín, Bogotá, Neiva y Tunja. Técnica de Selección de la Muestra: Probabilística, K sistemática. Se aplicó el test de sedentarismo de Perez- Rojas. Variables analizadas: Género, edad, estado civil, escolaridad, IMC y Actividad Física.
Resultados: El 53,4% fueron hombres, con una media de edad de 35,5 ± 12,9 años, estudios secundarios y/o universitarios en un 57,2% y un IMC cuya media fue de 24,5 Kg/m^2 ± 3,9 Kg/m^2. El dendograma mostró 2 grupos, activos y sedentarios; El grupo de activos residían en un 73% en Popayán, Bogotá, Medellín, Sincelejo y Armenia., entre los 18 y 24 años de edad, predominan los hombres, con IMC normal, realizaban ejercicio, con tiempo de práctica entre 30 y 60 minutos y tres veces a la semana. Los sedentarios eran el 27%, de las ciudades de Pereira, Neiva y Manizales. mayores de 35 años, predominantemente mujeres, solteras, no practican ningún nivel de actividad física, y presentan sobrepeso.
Conclusiones: El sedentarismo es un problema generalizado en las nueve ciudades estudiadas, se establecieron dos clases, en la clase sedentaria se destaca ser mujer, mayor de 35 años, tener sobrepeso y no realizar actividad física.

Palabras clave:
Movimiento. Adulto. Índice de masa corporal. Estilo de vida sedentario.

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Introduction

Physical inactivity is considered to be the time spent sitting down, which today also constitutes a worldwide concern and public health issue, with physical inactivity being the fourth highest mortality risk factor in the world[1,2]. Physical inactivity implies a minimum energy expenditure[3], and some of the activities considered to have low energy expenditure are sitting, lying, and leaning back watching television[4]. Different authors recommend limiting the consecutive time spent doing these activities, and establish that after 30 minutes of sitting, we should stand and perform some movements that may include stretching or taking a few paces, even if this is just walking around, with the aim of interrupting the amount of time spend being sedentary as much as possible[4-6].

In Latin America almost three quarters of the population has a sedentary lifestyle, a large part of the population of all ages is inactive, and women display a greater tendency to be sedentary, as do low-income demographics[7]. The proportion of the population whose health is at risk because of an inactive lifestyle is approximately 60%[8].

The information obtained regarding physical inactivity in Colombia is similar to international data. There are numerous studies claiming that the prevalence of physical inactivity is 52%[9]. These figures have been determined using universal instruments such as the International Physical Activity Questionnaire (IPAQ). In the search for even more precise and objective data, the level of physical inactivity has been measured in different cities in the country, applying the physical inactivity test[10]. The aims of this work were:

- To analyse the Body Mass Index (BMI) depending on the age, gender, civil status and physical activity.
- To determine the dendrogram and the groups to be analysed in this study.
- To analyse different variables depending on the previously obtained groups in the dendrogram (active vs. sedentary participants).

Materials and methods

Participants

A total of 4383 people from 9 cities in Colombia (Manizales, Neiva, Tunja, Pereira, Medellín, Popayán, Bogotá, Sincelejo and Armenia) participated in this study. The bioethics committee from the Autonomous University of Manizales approved this work.

Design

A correlating descriptive study with a multi-varied analysis, performed between 2012 and 2014, the levels of physical inactivity of the participants in the research were assessed. To gather the information an instrument designed by the researchers was used that was assessed by experts. The aim was to establish the socio-demographic variables of perception on the practice of physical exercise. This instrument was authorised by the people selected. Next the height and body weight were measured to calculate the BMI.

To define the level of physical inactivity, the physical inactivity test was applied[10] and once finished, the person was informed of their classification level according to the established test.

Material

The level of physical inactivity was assessed based on the physical inactivity classification test; its objectivity, reliability and validity were proven in the general population[10].

- The par-q questionnaire[11]: was applied to establish the cardiovascular risk, adding to the blood pressure reading using a blood pressure gauge and a LORD brand stethoscope, aspects defined as participant inclusion criteria.
- Heart rate: once the participant was established as apt to participate in the physical inactivity test, this was taken using the Fingertip Pulse Oximeter version 3.0.
- Test rhythm: an MA-30 KORG brand digital metronome was used.
- Execution timekeeping: measured with a SEIKO brand stopwatch.
- Physical Inactivity Classification Test: consisted in going up and down a 25 cm-high step at the rhythm of: 1st load 17 steps per minute for 3 minutes. After the 3 minute load was finished, the pulse rate was taken in the first 15 seconds of 1 minute of recovery. If the pulse rate remained below 120 beats/minute after one minute of recovery, the participant moved on to the second load. If the figure was higher, the test finished and a classification was given, in this case, sedentary. The second load followed the same procedure (26 steps per minute and the third load 34 steps per minute, always applying a 3-minute load and one minute of recovery)[10]. With this procedure, and in accordance with the participant's response, he/she was classified as severely sedentary, moderately sedentary, active or very active.
- BMI: To measure the weight, a Tanita digital scale was used and a height rod to measure the height.

For the statistical analysis, data about the heart rate was used, which enabled the final classification of the physical inactivity levels of the participants and the socio-demographic variables, BMI and physical activity that allowed for the final configuration of the clusters.

Statistical analysis

For the statistical analysis of the data, the SPSS 20.0 was used. The Cluster or Conglomerate analysis was taken with the SPAD version 4.1 statistics package, from which the dendrogram was constructed, which consisted in a graphical representation in the shape of a tree that summarised the individual grouping process; those with similar characteristics are connected with links whose position on the diagram is determined by the degree of similarity or dissimilarity between the individuals.

The normality test for quantitative values was established via the Shapiro-Wilk' test and the homoscedasticity via the Levene test. The agglomerative hierarchical method was used, meaning that each individual constitutes a small group, does not change group in the entire grouping process, until there is only one group which contains all the observations. The analysis metric was the Euclidean distance of the squared standardised variables table, and the conglomeration criteria used was the Ward system or the minimum variance criteria, whose objective is to minimise the variance between each cluster. The level of statistical significance was established at $p < 0.05$.

Results

Regarding age, this oscillated between 18-60 years with an average of 35.5 ± 12.9 years, the BMI with a range of 14.2-48.4 Kg/m^2 with an average of 24.5 ± 3.9 Kg/m^2. Table 1 displays the general description of the participants in terms of socio-demographic variables such as gender, civil status, level of education and physical activity undertaken.

The first approach for detecting the number of groupings or clusters is to perform a classification dendrogram. Once this has been performed, there are 2 clearly defined groups (cluster 1 and cluster 2), which are both homogeneous between individuals and heterogeneous between themselves (Figure 1).

Once the number of groups has been chosen the partition is obtained as well as the indicators of the homogeneity of the classes obtained. The partition of the classification tree in 2 classes has provided groups composed of 73% (n=3,194), and 27% (n=1,189) individuals respectively. Table 2 displays the inertia of each of the clusters and their distances to the centre of gravity of the sample. The most homogeneous and the smallest is class 2 (inertia 0.2741), class 1 is the most heterogeneous (1.1498) and includes the most individuals.

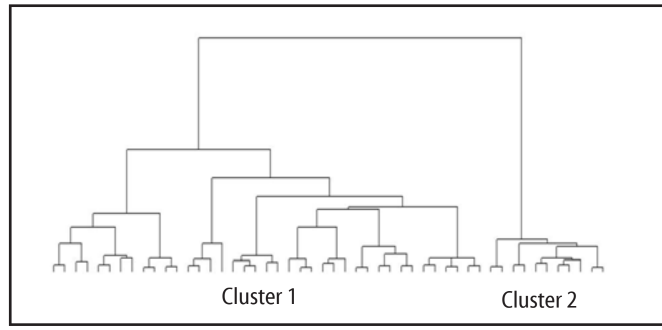
Figure 2 and Table 3 display the coordinates of the classes on the factorial axes and their test-values. The classes may be interpreted as well as the position of the individuals on the first factorial plane.

Class 1 is formed of 73% (n=3,194) of the people studied, 1,577 males and 1,617 females, aged between 18 and 24 years, in the BMI classification they are considered within the normal group. There is a prevalence of practising exercise, the time spent doing so is between

Table 1. General characteristics of the participating sample in this study.

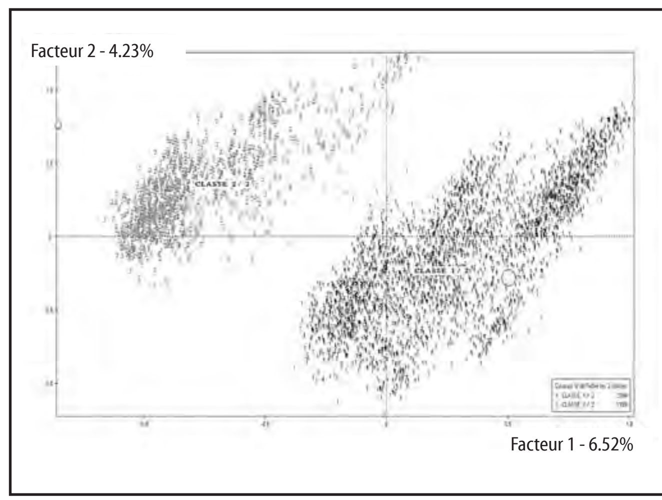
Variables	Category	Frequency	Percentage
Gender	Male	2,043	46.6
	Female	2,340	53.4
Civil status	Single	1,032	23.5
	Married	1,058	24.1
	Separated	346	7.9
	Divorced	437	10.0
	Widowed	1,104	25.2
	Free partnership	406	9.3
Level of education	No studies	54	1.2
	Primary	1,180	26.9
	Secondary	1,408	32.1
	University	1,117	25.5
	Others	624	14.2
Physical activity	None	1,191	27.2
	Physical activity	1,059	24.2
	Sport	603	13.8
	Exercise	1,530	34.9

Figure 1. Dendrogram of the cluster analysis.



The dendrogram shows the heterogeneity of all the individuals in the sample. Cluster 1 shows the majority of individuals (72.9%) and it is the class with the greatest inertia (1,232). Cluster 2 is the most homogeneous group and has less individuals, its inertia is just 0.2301.

Figure 2. Factorial plan of the classes.



The plan shows all the individuals divided in two large groups. Class 1 can be called the class or group of the active participants (non sedentary), whilst class 2 is the sedentary group.

Table 2. Breakdown of the inertia.

Inertia	Inertia	Strength	Distances
Inter-classes	0.2780		
Intra-classes			
Class 1	1.1498	3,194	0.1035
Class 2	0.2741	1,189	0.7467

The level of statistical significance was established at $p < 0.05$

Table 3. Coordinates and test-values about the factorial axes.

Classes	Test values		Coordinates	
	Axis 1	Axis 2	Axis 1	Axis 2
Clase 1	54.3	-30.7	0.29	-0.13
Clase 2	-54.3	30.7	-0.77	0.35

Table 4. Description of class 1: active participants

Variables	Categories	Percentage	Probability
Participant's city	Popayán	11.34	0.000
Participant's city	Bogotá	10.20	0.000
Participant's city	Medellín	12.07	0.000
Participant's city	Sincelejo	10.43	0.000
Participant's city	Armenia	10.15	0.001
BMI classification	Normal	52.91	0.004
Age by ranges	15-24 years	27.95	0.000
Civil status	Widowed	25.19	0.000
Weekly frequency	Once	26.26	0.000
Weekly frequency	Three times	15.20	0.000
Weekly frequency	Twice	12.75	0.000
Weekly frequency	Four times	9.83	0.000
Weekly frequency	Five times	8.76	0.000
Gender	Male	46.61	0.000
Level of physical activity	Exercise	34.91	0.000
Level of physical activity	Physical activity	24.16	0.000
Level of physical activity	Sport	13.76	0.000
Level of education	Others	14.24	0.000
Level of education	Primary studies	26.92	0.000
Level of physical inactivity	Active	31.30	0.000
Level of physical inactivity	Very active	13.39	0.000
Codified physical inactivity	Active	43.85	0.000
Time practising	Between 30 and 60 mins	29.02	0.000
Time practising	Over 60 mins	22.18	0.000
Time practising	Less than 30 mins	21.63	0.000

The level of statistical significance was established at $p < 0.05$

30 and 60 minutes, with a frequency of three times a week. They were classified in the physical inactivity level as active participants. Cluster name: Active participants (Table 4).

Class 2 is displayed in Table 5, and was made up of 27% (n=1,189), 725 women and 464 men, aged over 35 years, predominantly single women that do not practise any kind of physical activity, are overweight and are sedentary. Cluster name: Sedentary participants.

Table 5. Description of class 2: sedentary.

Variables	Categories	Percentage	Probability
Participant's city	Pereira	10.50	0.000
	Neiva	10.52	0.000
	Manizales	14.40	0.000
BMI classification	Overweight	34.57	0.007
Age by ranges	35-39 years	9.63	0.000
	50 plus	19.32	0.009
Civil status	Single	23.55	0.000
	Married	24.14	0.000
Gender	Female	53.39	0.000
Level of physical activity	None	27.17	0.000
Level of education	Students University	25.48	0.000
	Secondary students	32.12	0.006
Level of physical inactivity	Moderately sedentary	36.37	0.000
	Severely sedentary	18.94	0.000
Codified physical inactivity	Sedentary	56.15	0.000

The level of statistical significance was established at $p < 0.05$

Discussion

The general aim was to establish the level of physical inactivity in the population aged between 18 and 60 years, in nine Colombian cities. The results reveal a greater level of physical activity among men aged between 18 and 24, and the reduction of physical activity with age. Different studies suggest that these inequalities in sex in physical activity levels may be due to the different attitude that men and women have towards physical exercise[12-14]. Specifically, men consider sporting activities as congruent to the masculine role and acquire prestige through competition, whilst women are less likely to relate sporting activity with the process of being a woman, which may mean they avoid participating in any activities that may be perceived as threatening to their femininity[15].

An aspect that may be affected by cultural factors, and as presented by Inchley and Currie[16], is that the existing norms for practising physical activity have been less restrictive for men. Despite this analysis not focusing on the state of health, there is a positive link between a high level of physical activity during youth and other important health indicators, such as the perception of health, emotional well-being and life satisfaction[17-21].

Likewise both sedentary conduct and physical activity are perfectly compatible because they occur at different times of the day[21].

In terms of the BMI, the results of this study are consistent with the research that establish positive connections between this and levels of physical inactivity. (24,5 ± 3,9 Kg/m^2, *vs* 24,18 ± 3,61 Kg/m^2; 24, 4 ± 3,45 kg/m^2)[13,22]. Some research studies on physical inactivity describe subjects with high levels of physical inactivity as sedentary; over 60% of adults over 17 years suffer from excess weight or obesity, the majority of which results from not just inactivity, but also from poor eating habits[22-25].

In accordance with that established in the results of this study, the participants are associated to two groups: active and sedentary participants. The group of active participants corresponds with the criteria established for the practice of physical activity, it mainly consists of men aged between 18 and 24 years, with a normal BMI, mainly performing exercise, spending 30 and 60 minutes doing so and performing exercise three or more times a week.

This information is similar to that suggested by González *et al*[26], who state that the factors that increase the possibility of complying with recommendations to perform physical activity in leisure time were age (18-29 years), a secondary or higher level of education, being a student, looking for work, working in home jobs or retired and not being disabled.

The participants in group 1 revealed a tendency to uphold the universally established criteria for practising physical activity, changes can be seen in the lifestyle habits of the population, including using a bicycle, walking and practising sports, among others. This conduct is displayed to a greater extent in participating males, data that is coherent with that found by Muros *et al*[27], who highlight that 79.66% of male subjects prove to be active compared to 40.43% of women who are active.

Cluster 2 was formed by 27% of people, residing in the cities of Pereira, Neiva and Manizales. They are over 35 years, predominantly female, single, do not practise any kind of sport, are overweight and are sedentary. This data is coherent with that found in other studies that reveal that a large percentage of women lack physical activity and present sedentary conduct[28-30]. Likewise, it is important to highlight that in Latin America almost three quarters of the population has a sedentary lifestyle, a large part of the population of all ages is inactive, and women display a greater tendency to be sedentary, as do low-income demographics[31].

Conclusions

In the Colombian context the results of this study enable the determination of sedentary behaviour in the population studied based on the study of physiological variables such as the heart rate, which objectively highlights a widespread problem, suggesting that measures should be taken in public policy in the search for behavioural changes.

There are variables that are associated with levels of physical inactivity in the population studied in each of the conglomerates; in particular being female, over 35 years, overweight and not practising physical activity.

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