Short-term adaptations in sedentary individuals during indoor cycling classes

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Recibido: 30.01.2015
Aceptado: 18.05.2015

Summary

Indoor cycling (IC) has recently been increasing in popularity and gaining recognition as an effective training activity. However, few studies have investigated the benefits of IC for sedentary participants, and the electrical activity of muscles during IC classes, in fitness clubs, has not been reported. The aim of this study was to compare muscle activity, heart rate (HR), and subjective effort between two groups (sedentary participants and trained teachers of the fitness club), over three IC classes. Thirty-eight volunteers were split into two groups according to their fitness status and weekly training load. Each participant completed three IC classes in a private gym over separate days. Variables were compared both between groups and within classes. Exercise intensity, assessed using the HR, was similar in both groups. The subjective perceived effort, assessed using the Borg Scale, was significantly higher in the sedentary group. However, the surface electromyographic (sEMG) data showed adaptive responses in this group after three classes. There was a trend for a gradual reduction in fatigue in sedentary participants, especially for the gluteus maximus and biceps femoris muscles, raising doubts regarding the inclusion of individuals with different training levels in the same class. The root mean square and median frequency of the sEMG data changed over the three IC classes, indicating adaptation to fatigue in the sedentary group, but not in trained participants. Thus, IC can be incorporated into protocols for sedentary individuals, but the short-term adaptation suggests that developing a specific class/protocol for beginners might be appropriate. They could then be included in an advanced class after the third day of training.

Key words:
Bicycling. Muscle fatigue. Electromyography. Motor performance.

Adaptaciones a corto plazo en individuos sedentarios durante las clases de ciclismo indoor

Resumen

Ciclismo indoor (CI) está ganando reconocimiento y popularidad en los últimos años y pocos estudios han investigado los beneficios para los participantes sedentarios. No se han publicado estudios sobre la actividad eléctrica de los músculos que participan en las clases reales de CI. El objetivo de este estudio fue comparar el tiempo y el efecto del grupo en las variables de la actividad eléctrica muscular, frecuencia cardíaca (FC) y el esfuerzo subjetivo en ambos grupos (profesores sedentarios y entrenados en un gimnasio). Treinta y ocho voluntarios fueron divididos en dos grupos de acuerdo a su estado de entrenamiento semanal. Cada sujeto completó en días separados, tres clases CI en un gimnasio privado. Las variables se compararon entre los grupos y entre las clases. La intensidad del ejercicio que llegaron los sujetos, en términos de FC, fue similar en ambos grupos, aunque el esfuerzo subjetivo, medido por la escala de Borg, mostró diferencias significativas en la percepción del esfuerzo entre los grupos, siendo mayor en el grupo sedentario. Sin embargo, los datos muestran respuestas sEMG adaptativas en este grupo después de tres clases. Hubo una tendencia de reducción gradual de la fatiga en sedentarios, especialmente para GM y BF, y hace cuestionable la inclusión de las personas con diferente nivel de entrenamiento en el mismo salón de clases. Los resultados mostraron que tres clases de CI llevaron a cambios de comportamiento en el RMS y en la FM, lo que indica la adaptación a la fatiga en el grupo sedentario, pero no en los entrenados. Por lo tanto, IC puede ser incorporado en los protocolos para sedentarios, pero esta adaptación a corto plazo a la fatiga sugiere la posibilidad de posibilidad de nuevos estudios, con clase / protocolo específico para los principiantes. Ellos podrían ser incluidos en la clase avanzada a partir del tercer día de entrenamiento.

Palabras clave:
Ciclismo. Fatiga muscular. Electromiografía. Rendimiento motor.

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Introduction

Regular participation in cardiorespiratory training elicits cardiovascular improvements, which attracts many people to private gyms and fitness clubs. Indoor cycling (IC) is one of the activities available at these venues and it has become increasingly popular in recent years. IC is characterized by workout steps, as well as variable intensity and involvement of both the cardiovascular system and skeletal muscles. Participants often perform the classes in a dimly lit fitness room, where they cycle to loud rhythmic music in a group on stationary bikes; the teacher provides verbal motivation and instructions[1,2]. IC classes are thought to expend a large amount of energy and are usually very demanding and challenging for participants. They have also been described as an excellent way of losing weight as part of a fitness program[3].

Despite its worldwide popularity, few scientific studies have assessed the impact of IC on metabolic and cardiovascular functions[1,3]. and surface electromyography (sEMG) has only been used in studies with outdoor cycling sessions[4,5], or with common stationary bikes[6]. sEMG is a useful tool to assess musculoskeletal recruitment patterns, neuromuscular adaptations, and fatigue. IC classes have completely different features (e.g. rhythm, loud music, verbal motivation) to other kinds of training[6]. This study, which focuses on IC, is therefore novel research, which adds to information in this area.

It is unclear whether IC is a fitness activity that should be undertaken by sedentary people (including the elderly and other specific groups, such as those unfamiliar with cycling), who want to begin a physical activity program. It is well known that training leads to important cardiorespiratory and muscular adaptations[7]; therefore, we wished to investigate how the commands given by a highly trained teacher should be perceived and executed by each student. Some authors describe IC as a strenuous physical activity, which is not suitable for everyone[8]. Bianco *et al* (2010)., on the other hand, concluded that IC lessons can be adapted to all fitness levels[3]. International recommendations exist on the monitoring of training, including the use of HR bands for safety[2]. However, there can be difficulties in estimating the intensity of exercise performed by participants in IC classes in fitness clubs, since chest HR transmitters and wrist monitor recorders are not available to everyone. This exposes the participants to risks. In fact, participants who do not bring their own devices, only have a subjective perception of their effort and of the exercise intensity.

The aim of this study was to evaluate the time course of the sEMG variables, HR, and subjective effort in sedentary participants while they performed three IC classes and to compare their results with the trained teachers of the fitness club. We hypothesized that teachers, as high-level cyclists, would also adopt a more efficient strategic pedaling technique, which might prevent early fatigue, and that this might be observed from the sEMG results.

Material and methods

Participants

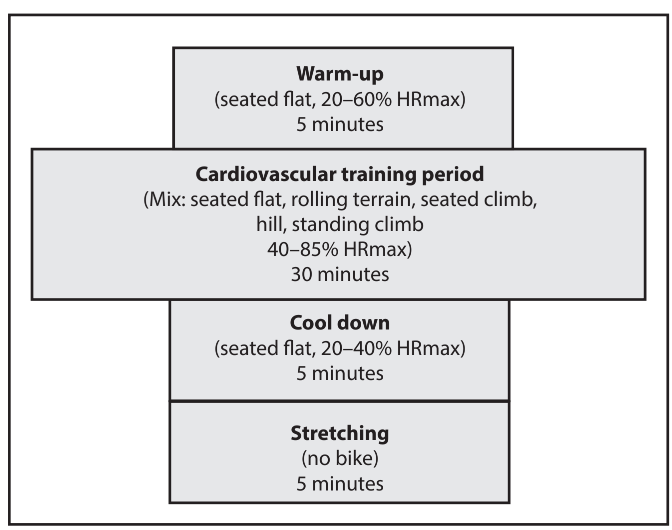
Thirty-eight volunteers were allocated to two groups according to their fitness status and weekly training load. The trained participants (n = 10) were all IC instructors of fitness clubs, had been regularly teaching IC classes for at least five years before the study, and, on average, taught five classes a day, four times a week. The sedentary group (n = 28) comprised new clients from fitness clubs, who engaged in less than 150 minutes of moderate-intensity exercise each week (ASCM guidelines) and had never experienced an IC class prior to the current study. The exclusion criteria included a history of musculoskeletal dysfunction or trauma in the past 24 months and any training on a cycle ergometer (for the sedentary group). During their participation, participants were asked to refrain from alcohol and caffeine. Each volunteer signed a consent form and the protocol was approved by the Federal University of Pará's human ethics committee (204/11).

Procedures

After a few pedalings (15–20 rides) for familiarization with the bike, the participants performed three pedaling with maximum load (Maximum load pedaling - MLP) to record the maximum voluntary electrical activation. They were instructed to pedal the bike while the load was gradually increased until the pedals came to a complete stop. The last complete cycle was used for calculations, in line with a technique adapted from Rouffet and Hautier[9]. The mean value of the three tests was used to normalize all sEMG data.

Each participant completed three IC classes, lasting 45 minutes each. These were completed on separate days, with an interval of 48 hours between them. All procedures took place in a private gym, during the evening (between 18:00 p.m. and 21:00 p.m.; room temperature and relative humidity of 22±2.7 ºC and 48±4.5%, respectively). The researchers did not change the protocol used by teacher for the IC class; this encouraged the participants to follow the recommended pedaling frequency and cycle resistance, within their limitations. The classes were always the same and were divided into four stages: warm-up (5 min), cardiovascular training period (30 min), cool down (5 min), and stretching (5 min), as presented in Figure 1. All calculations and analysis were related to the cardiovascular training period.

Figure 1. Structure of the class.



HRmax: Maximum heart rate.

The HR was recorded by using a chest HR transmitter worn by the participants and a wrist monitor recorder (Polar FT7, USA). The data from the entire class were downloaded via a Flow Link interface and the mean values over every 5 s during the class were calculated. After the end of each class the participants' effort on the Borg Scale of Perceived Exertion (Borg Scale) was collected, by asking them to choose, from 0 to 10, the number that best represented their level of tiredness[10]. All data were processed and analyzed using MATLAB (Matlab10; Mathworks Inc., Natick, MA, USA).

EMG data acquisition and analysis system

Disposable surface electrodes (Meditrace Al/AgCl) with a 10-mm diameter were used. The electromyographic signals were recorded through a bipolar arrangement with an inter-distance of 20 mm. Surface electrodes were placed on the skin of the dominant leg, parallel to the direction of muscle fibers, to record the electrical activity of the gluteus maximus (GM), biceps femoris (BF), rectus femoris (RF), and semitendinosus (ST) muscles. The reference electrode was attached on the olecranon, in line with SENIAM guidelines[11]. An 8-resolution channel data acquisition system (model EMG820C, Emgsystem Inc.; São José dos Campos, Brazil), consisting of a signal conditioner with a band-pass filter of 20-450 Hz and amplifier gain of 2000, was used to obtain the biological signals. All data were processed and exported for analysis by specific software (EMGLab EMG system, Inc.). sEMG activity was captured by using differential surface electrodes (SDS500) and converted with an A/D board (EMG Sys 30306, EMG System do Brasil, Brazil) with 14-bit resolution input range, sampling frequency of 2000 Hz, common rejection module greater than 100dB, signal-to-noise ratio less than 0.3 μV, and impedance of 109 Ω.

The root mean square (RMS) data was acquired from the raw EMG data by full-wave rectification using a continuous average. The time constant was set as 400 ms as recommended previously[12]. In order to reduce variations and condense the data, the system averaged the RMS values in 10-s epochs and normalized the data relative to the maximum voluntary electrical activation when pedaling with MLP[9]. The power spectra density from every 1024 samples (1 s period) was calculated using a fast Fourier transformation and the median frequency (MF) was determined. Both the RMS and MF were only calculated during onset of muscle activation. The criteria for establishing the onset and offset activation were based on a voltage threshold (three standard deviations beyond the mean value during baseline)[5,13]. The RMS and MF were analyzed over time using linear regression.

sEMG data were analyzed using a pre-specified routine described in MATLAB and the following variables were compared both between and within groups: MF variation (initial MF – final MF) and RMS variation (initial RMS – final RMS). The initial MF and initial RMS relate to the first 5 minutes of the cardiovascular training period. The final MF and final RMS relate to the last 5 minutes of the same period.

In addition, sEMG data were expressed as a pair of parameters representing the slopes of the RMS and MF in the joint analysis of spectra and amplitude (JASA) plot, as previously proposed by Lin *et al.*[14]. With this method, both characteristics of the EMG are considered, and represent muscle behavior according to the quadrants methodology as follows:

- Upper-right quadrant: increase in both RMS and MF, indicating an increase in muscle force.
- Lower-right quadrant: increase in the RMS with decrease in the MF, indicating muscle fatigue.
- Upper-left quadrant: decrease in the RMS and increase in the MF, indicating the adaptation of the involved muscles.
- Lower-left quadrant: decrease in the RMS and decrease in the MF, indicating decline in force produced.

Therefore, lower quadrants express decline of force and fatigue and are a signal of physiological failure.

Statistical Analysis

The sample size was estimated using SigmaStat 3.5. Assuming a confidence interval of 95% and power of 80%, the required sample was determined to be 10 per group. Data were tested for normality using the D'Agostino test. Data are presented as mean and standard deviation. The statistical analysis was performed with SPSS (version 15.0, SPSS Inc., Chicago, USA). For the parameters considered, the overall differences between the groups (group effect) and the interaction between the classes and group factors (class-group effect) were tested with general linear model statistics. Post-hoc tests were carried out using the Sidak procedure.

Results

General details

Four sedentary participants (14.3%) withdrew from the study due to micro traumas or pain following the first class. Table 1 shows the demographic characteristics of participants.

Figure 2 contains an example of a raw EMG signal from one participant during the three IC classes (training cardiovascular and cool down period).

Heart rate and subjective effort

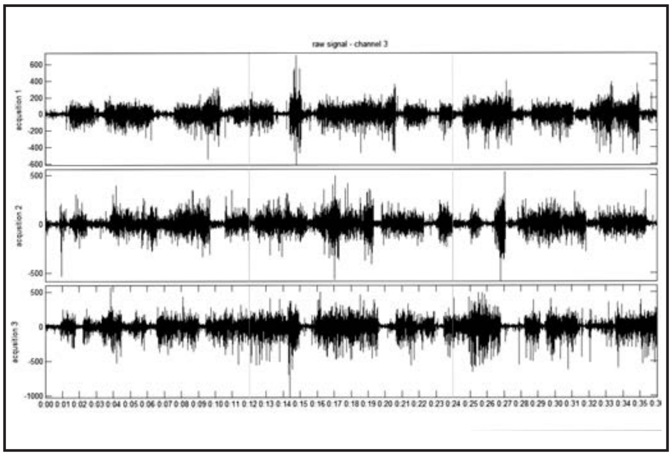
The trained group showed a significantly lower level of fatigue on the Borg Scale ($p = 0.001$) and a lower HR in comparison with the

Table 1. Demographic characteristics of the participants.

Variables	Sedentary participants (n=28) Mean (SD)	Trained (n=10) Mean (SD)	*p*-value
Age (years)	24.0 (2.1)	27.0 (4.4)	0.06
Weight (kg)	57.6 (1.6)	62.7 (1.9)	0.09
Height (m)*	1.65 (1.61)	1.69 (1.56)	0.12
BMI (kg/m^2)	23.9 (1.7)	22.3 (1.3)	0.06
Resting HR (beats/min)	82.73 (6.16)	63.77 (3.54)*	0.03*

Mean and standard deviation (SD): age, weight, height, BMI, Resting HR. *$p < 0.05$, differences between groups.

Figure 2. Raw EMG recorded for the rectus femoris muscle during the three acquisitions (recorded during 35 minutes of cardiovascular training and cool down period of IC classes). Participant 9, trained group.



sedentary group (p = 0.004). In addition, there was a significant class-group interaction on the level of fatigue on the Borg Scale (*p* = 0.002), as presented in Table 2.

sEMG data

Figure 3 depicts the RMS variation measured for both groups. All muscles considered in the sedentary group had higher RMS levels than those in the trained group. There was also a class-group interaction for all muscles, except for the RF. In the trained group, the RMS variation was not significantly different between classes, for any muscle.

As shown in Figure 4, for the GM and BF, the MF variation in the first class was significantly higher in the sedentary group than the trained group. For sedentary participants, the MF decreased significantly over the three classes for both GM and BF. In trained participants, the MF variation was not significantly different between classes, for any muscle. The p-values for all comparisons are shown in Table 3.

Figure 3. RMS variation (% MLP) during 3 IC classes in trained and sedentary groups.

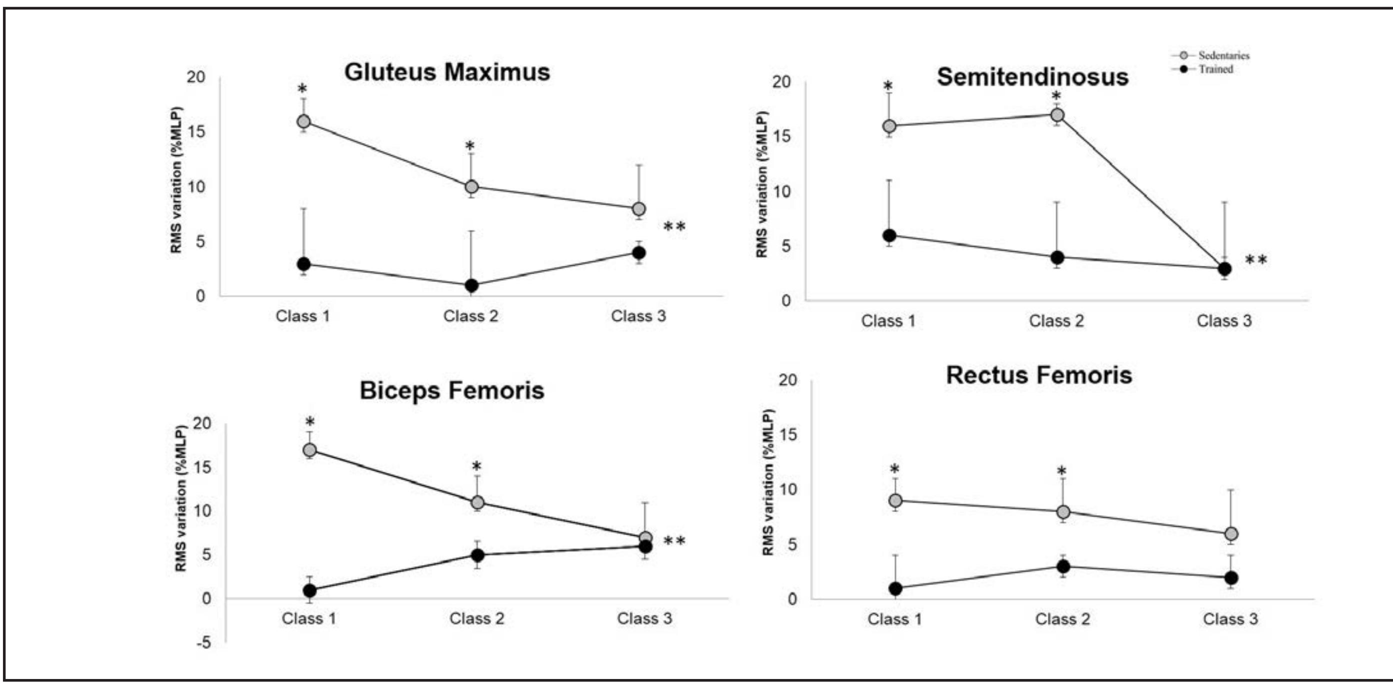


Table 2. Comparison between groups and IC classes.

	Mean heart rate (beats/min)					Borg Scale of Perceived Exertion				
	Class 1	Class 2	Class 3	Group effect	Class-group effect	Class 1	Class 2	Class 3	Group effect	Class-group effect
Trained	135.3 (2.7)	136.7 (2.4)	137.8 (2.3)	p = 0.004	p = 0.53	4.1 (1.1)	4.2 (0.7)	3.9 (1.3)	p = 0.001	p = 0.002
Sedentary	152.3 (4.7)	146.7 (3.3)	147.9 (1.6)			10 (0)	9.2 (0.7)	9.9 (1.3)		

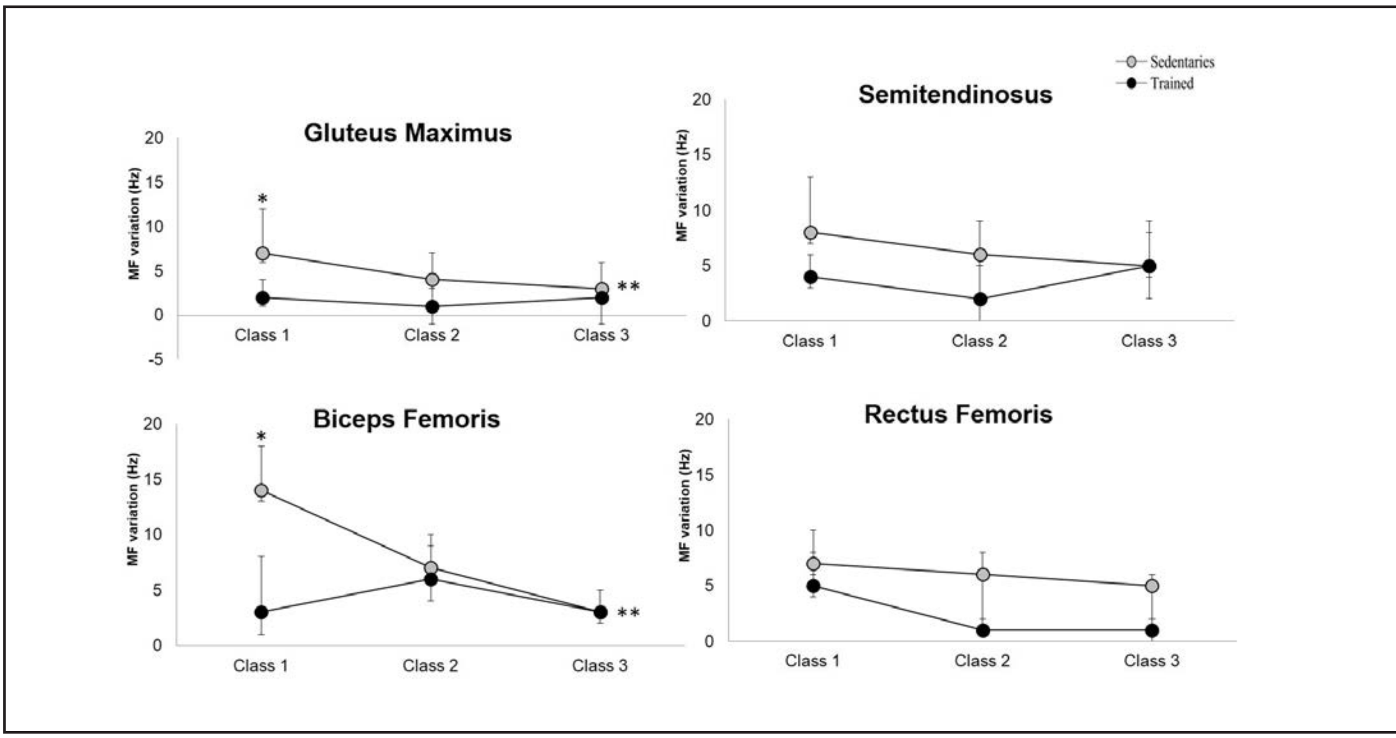
Mean heart rate and subjective effort assessed using the Borg Scale in IC classes for both groups. Values are given as mean (SD).

Table 3. Significance of group effect and class/group effect (p-values).

	RMS				FM			
	BF	GM	RF	ST	BF	GM	RF	ST
Group effect, Class 1	0.0000*	0.0000*	0.0042*	0.0072*	0.0040*	0.0100*	0.3500	0.2158
Group effect, Class 2	0.0023*	0.0001*	0.0032*	0.0002*	0.2350	0.1260	0.1350	0.4550
Group effect, Class 3	0.0923	0.0824	0.1230	0.2532	0.1269	0.4563	0.7369	0.1458
Class/group effect	0.0026*	0.0018*	0.2724	0.0001*	0.0006*	0.0172*	0.0943	0.3596

ANOVA tests (p-values), *$p < 0.05$

Figure 4. MF variation (Hz) during 3 IC classes in trained and sedentary groups.



JASA method

Tables 4 and 5 summarize the JASA analysis of the 10 trained and 24 sedentary participants, respectively.

For the GM, 50% of the 10 participants in the trained group and 83% of the 24 participants in the sedentary group manifested muscle fatigue or force decrease after the first class. This number remained unchanged for the trained group, but progressively decreased to 37% after the third class in the sedentary group. For the trained group, all of the other muscles showed significant differences in the distribution, when compared over the three classes. In contrast, in the sedentary group, for each muscle, there was a gradual reduction of participants in the lower quadrants over the three classes. The results for GM and BF show a significant reduction in the number of participants that fell into these lower quadrants (which represent fatigue and decrease in force).

Discussion

The main purpose of this study was to evaluate the exercise intensity pattern of an IC class in a real setting (fitness club) and to compare inexperienced sedentary individuals with trained instructors. Previous studies stated that IC is a high intensity exercise, but none assessed the EMG activity[1,3].

Our results showed that the exercise intensity, in terms of the HR, was significantly higher for the untrained group, but there was no class-group effect. This means that the HR reached by all participants similarly ranged from moderate to very high. However, the subjective perceived effort, measured by the Borg Scale, was significantly higher for sedentary participants (positive class and group effect). The nature of this exercise explains the high subjective effort reported. Some authors recommend

Table 4. Summary of RMS, MF distribution in the four quadrants of JASA plot for muscles in trained group (n = 10).

Quadrant in JASA plot	EMG measurements									
	RMS	MF	GM		ST		BF		RF	
Class I										
Force increase	+	+	3	50%	4	70%	5	80%	1	30%
Adaptation	-	+	2		3		3		2	
Fatigue	+	-	2	50%	2	30%	1	20%	2	70%
Force decrease	-	-	3		1		1		5	
Total			10		10		10		6	
Class II										
Force increase	+	+	4	50%	1	30%	2	50%	4	50%
Adaptation	-	+	1		2		3		1	
Fatigue	+	-	2	50%	2	70%	3	50%	2	50%
Force decrease	-	-	3		5		2		4	
Total			10		10		10		10	
Class III										
Force increase	+	+	2	50%	4	70%	3	70%	2	50%
Adaptation	-	+	3		3		4		3	
Fatigue	+	-	2	50%	2	30%	2	30%	2	50%
Force decrease	-	-	3		1		1		3	
Total			10		10		10		10	75
p value				1		0.4		0.47		0.79

RMS: root medium square; MF: median frequency; GM: gluteus maximum; ST: semitendinosus; BF: biceps femoris; RF: rectus femoris; +: slope increase; - slope decrease. * chi-square test (significance 0.05).

Table 5. Summary of RMS, MF distribution in the four quadrants of JASA plot for muscles in sedentary group (n = 24).

Quadrant in JASA plot	EMG measurements									
	RMS	MF	GM		ST		BF		RF	
Class I										
Force increase	+	+	3	17%	5	37%	6	29%	6	37%
Adaptation	-	+	1		4		1		3	
Fatigue	+	-	6	83%	4	63%	7	71%	4	63%
Force decrease	-	-	14		11		10		11	
Total			24		24		24		24	
Class II										
Force increase	+	+	4	37%	7	37%	7	46%	6	37%
Adaptation	-	+	5		2		4		3	
Fatigue	+	-	4	63%	4	63%	4	54%	1	63%
Force decrease	-	-	11		11		9		14	
Total			24		24		24		24	
Class III										
Force increase	+	+	11	63%	10	50%	8	58%	10	40%
Adaptation	-	+	4		2		6		2	
Fatigue	+	-	3	37%	4	50%	2	42%	0	60%
Force decrease	-	-	6		8		8		12	
Total			24		24		24		24	
p value				0.01*		0.1		0.04*		0.45

RMS: root medium square; MF: median frequency; GM: gluteus maximum; ST: semitendinosus; BF: biceps femoris; RF: rectus femoris; +: slope increase; - slope decrease. * chi-square test (significance 0.05).

that the exercise intensity for novice individuals should be lower than the 50-85% recommended by ASCM[8]. They also suggest that the volume of standing climb during the classes should be reduced for novices[1]. In our study, the teacher instructed participants to increase intensity when cycling on the stationary bikes, but this was done voluntarily and at a level chosen by the participant. The participants applied the teacher's command in a rotary actuator on the bike, deducting subjectively the amount of load. Furthermore, the teacher requested the participants to control their effort using their HR reading. This was done with reference to their maximum HR (HRmax), which was calculated using the formula 220-age beats/min. However, consistently quantifying participants' effort can be an issue, since the use of chest HR transmitters is a practice not typically followed by the fitness club, and only the participants in our study received one.

Many studies have attempted to provide analysis of pedaling, and have investigated issues such as characterization of lower limb muscle activation patterns, level, timing, coordination or fatigue[4,5,9,15-17]. However, none of these were carried out during a real set (IC class), in a fitness club environment.

In our study, separate and joint analyses of RMS and MF values were used to compare the behavior of individuals, who had not previously taken part in IC with trained instructors.

The RMS values of all four muscles were significantly higher in the sedentary group, in all classes. The performance comparison between trained and untrained muscle in conventional cycling has been previously studied[18,19] and it is known that high-level cyclists often adopt a pedaling technique that allows the agonist and antagonist muscles in the leg to pedal more efficiently[7]. As showed in our results, trained cyclists had lower RMS values for the same load, meaning that their muscles can perform the biomechanics of cycling with less intensity, which preserves this group from early fatigue[15,20].

Despite this expected result, it was also evident that there was a decreasing RMS trend, in the evolution of the three classes, in the muscles of the sedentary participants. In the literature, it is well documented that the repeated performance of a task facilitates neuromuscular adaptations in response to overload, resulting in more skilled movement, and changes in patterns of muscle activation. This improved movement control is characterized by decreased amplitude and duration of muscle activity in the electromyogram[21,22].

The MF variation was significantly higher in the GM and BF in the sedentary group for the first class. It was also evident that there was a trend of high variations in the sedentary group, especially in the first and second classes. This demonstrates that the sedentary group experienced more fatigue than the trained group, and that this difference was more evident in the initial classes.

We also used the JASA method to consider both RMS and MF over all the classes. The JASA results supported the isolated RMS analysis and showed a significant decrease in the number of participants who fell into the lower quadrants, representing fatigue, in the later classes. No differences were seen in the trained group. This indicates that the sedentary group adapted to the exercise over the three IC classes, whereas the trained group did not.

It has been proposed that greater cycling efficiency, and more economical cadence, are evidence of skilled muscle recruitment in highly trained cyclists[15,20,23,24], and that this prevents early fatigue. Our findings are consistent with this hypothesis. However, it is interesting that this adaptation appeared to occur over only three IC classes.

Three stages of learning have been proposed: the cognitive, associative, and autonomous stages[25]. After extensive practice, the performer reaches the autonomous phase, which is characterized by fluent and seemingly effortless motions. Thus, performance improves motor skills, and this is seen in trained cyclists.

Nevertheless, the amount of training necessary to really change performances is a controversial issue[26]. Several authors have suggested peripheral adaptations, assessed by sEMG, as effects of short-term training, but they had considered workouts of longer than 3 weeks[27,28]. Creer *et al.* concluded that, in a trained cycling population, four weeks of high-intensity sprint training, combined with endurance training, increased motor unit activation more than endurance training alone. In contrast, there is evidence in the literature to suggest that neuroplastic changes can occur over very short training intervals[29-31]. Wiemann and Hahn (1997) compared the effect of short-term training on the muscle activity of the hamstrings. The authors showed significantly decreased RMS values in participants after stretching and stationary cycling performed for only 15 minutes[32].

IC requires considerable effort and there are doubts about its suitability for sedentary people. These findings suggest that IC can be incorporated into protocols for this population, but their fitness levels should be taken into account because each performance depends on the individual's physical fitness. Short-term adaptations to fatigue were seen in the neuromuscular activation and this corroborates the need for further study in the area. This could include the possibility of developing a specific class/protocol for beginners, who might then be included in an advanced class after the third day of training.

In summary, the Borg Scale responses indicated that the IC classes were more exhausting for the sedentary group, although the sEMG data showed adaptive responses in this group after three classes. There was a trend for a gradual reduction in fatigue in this group, especially for GM and BF muscles and this raises doubts regarding inclusion of individuals with different training status in the same class.

Acknowledgement

MS/ FAPESPA- PPSUS 003/12 and PROPESP/UFPA- PIBIC. CAPES-COFECUB project n°819-14.

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