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ORIGINAL

ACUTE EFFECTS OF EXERCISE ON MOOD AND HRV

EFECTOS AGUDOS DEL EJERCICIO FÍSICO SOBRE EL ESTADO DE ÁNIMO Y LA HRV

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ABSTRACT

The aim of this study was to analyze the acute effects of exercise on mood and on heart rate variability (HRV), in active and sedentary people. This involved 30 undergraduates classified into Active and Non active participants. In a single session participants performed a submaximal exercise test (UKK), answered the Profile of Mood States (POMS) and performed before and after the exercise a test of HRV at rest. The participants improved their mood state, by increasing Vigor and Fatigue factors and decreased Tension and Depression after the exercise test. Moreover, Active participants presented a significant higher decrease in Depression after exercise than Non active. HRV analysis also showed differences between Active and Non active participants in the frequency domain parameters LFnu2 and HFnu2.

KEY WORDS: Physical exercise, mood, POMS, heart rate variability, HRV.

RESUMEN

El objetivo del estudio es analizar los efectos agudos del ejercicio físico sobre el estado de ánimo y la variabilidad de la frecuencia cardíaca (HRV), en personas activas y sedentarias. Para ello participaron 30 estudiantes clasificados en *Activos* y *No activos*. En una sola sesión realizaban una prueba de esfuerzo submáximo (UKK), cumplimentando el Perfil de Estados de Ánimo (POMS) y realizando un test en reposo de la HRV antes y después del ejercicio. Los resultados indican una mejora en el estado de ánimo, aumentando en los factores de Vigor y Fatiga y disminuyendo en Tensión y Depresión después del ejercicio. Se encontraron diferencias significativas en función del nivel de ejercicio físico de los participantes en el nivel de Depresión, al observarse una mayor disminución después del ejercicio en los *Activos*. La HRV también mostró diferencias entre *Activos* y *No activos* en los parámetros de dominio frecuencial, LFnu2 y HFnu2.

PALABRAS CLAVE: Ejercicio físico, Estado de ánimo, POMS , Variabilidad de la frecuencia cardiaca, HRV.

INTRODUCTION

In developed countries, a high sedentary behaviour among the population has been noted (Parrado, Cervantes, Ocaña, Pintanel, Valero & Capdevila, 2009). The different applications of the new technologies and the range of free-time activities which avoid any physical exertion have led to changes in people's behaviours which distance them from active lifestyles (Niñerola, Capdevila & Pintanel, 2006) at the expense of health. For this reason, studying the effect of physical exercise on physical health has surfaced as a pressing topic. In parallel, with the growing interest in studying psychological wellbeing and the interventions aimed at fostering a state of overall wellbeing (Gilbert, 2006; McMahon, 2006; Reigal, Márquez, Videra, Martín & Juárez, 2013). Numerous studies have confirmed the benefits of physical exercise in different spheres of psychological wellbeing (Jiménez, Martínez, Miró & Sánchez, 2008), improvements in subjective health, mood and emotions (Biddle, Fox & Boutcher, 2000; Arruza, Arribas, Gil De Montes, Irazusta, Romero & Cecchini, 2008; Ruiz y Baena, 2011; Candel, Olmelilla & Blas, 2008; León-Prados, Calvo-Lluch & Ramos-Casado, 2012; Reigal & Videra, 2013) and increases in self-esteem (McAuley, Mihalko & Bane, 1997; Huertas, López, Pablos, Colado, Pablos-Abella & Campos, 2003), among other effects. However, the effects of practising physical exercise on psychological health has not been as solidly established as the effects that it has on physical health, because of the difficulty of performing experimental studies aimed at establishing a cause-effect relationship between practising physical exercise and mental health. Therefore, the majority of studies in this field have adopted less rigorous methodological designs (Jiménez et al., 2008). On the other hand, two general procedures have been established to analyse the acute effects of physical exercise after performing occasional physical exercise and the chronic effects of physical exercise, analysing the changes over time (Moya-Albiol & Salvador, 2001).

The repercussions of physical exercise on different levels of health have been analysed based on different parameters (frequency, duration, intensity, type of exercise, etc.). Previous studies have suggested that performing moderately intense exercise such as walking for a short session, just ten minutes long, may be enough to see a beneficial change in mood (Hansen, Stevens & Coast, 2001; Anderson & Brice, 2011; Focht, 2013). In turn, healthy exercise is the kind that uses between 50% and 85% of maximum oxygen consumption (Arruza, Arribas, Gil De Montes, Irazusta, Romero & Cecchini, 2008), which can be measured during Maximum Heart Rate (HR_{max}), in which 70% of maximum oxygen consumption would be equivalent to 80% of the HR_{max} (Beachle & Earle, 2008). The association between practising moderate physical exercise and its effect on mood has been studied in healthy sedentary individuals, in special populations and in clinical populations, and these studies indicate that moderate exercise increases the sense of vigour and lowers the sense of fatigue, depression and anxiety in the participants (León-Prados et al., 2012). Similar results were obtained in studies which observed an evolution in mood throughout a physical activity programme (Torres, G., Torres, L., Zagalaz & Villaverde, 2010), as well as in studies which have examined the effect of a single session of physical exercise on mood (Anderson & Brice, 2011; Reigal, Márquez, Videra, Martín & Juárez, 2013; Reigal & Videra, 2013). In this kind of study, it is important to be rigorous in the methodological approaches and research designs and to specifically define the processes carried out (Rehor, Dunnagan, Stewart & Cooley 2001). The kind of exercise performed must also be stated, along with its intensity, frequency and duration, so that the results can be as reliable and precise as possible, since not all type of exercise have the same effects (Jiménez et al., 2008; Reigal & Videra, 2013). One limitation of this kind of study is that they do not measure the intensity objectively; that is, they use no instrument that measures the impact of the physical exercise on the participants' body. These studies usually define the kind, duration and intensity of the exercise, but the latter is not controlled objectively so it is impossible to establish a cause-effect relationship since the intensity may be different in each participant.

On the other hand, heart rate (HR) is one of the most commonly used non-invasive parameters to assess heart activity. Heartbeats occur with a variable frequency, which is known as heart rate variability (HRV); this occurs as a result of the interaction between the autonomous nervous system (ANS) and the cardiovascular system (Carballido, Rodas, Ramos & Capdevila, 2008). HRV is a useful tool in situations such as practising physical exercise (Cottin, Medigue & Papelier, 2008; Leti & Bricout, 2013) because it provides a reflection of the modulation of the ANS. Generally speaking, physical exercise provides psychological benefits as well as sound physical condition, which are associated with the functioning of the ANS (Sakuragi & Sugiyama, 2006). For example, it has been noted that after a period of aerobic training, individuals show higher levels of aerobic capacity (measured by $VO2_{max}$) and higher levels of vagal control of the heart rate (measured via HRV) (Hansen, Johnsen, Sollers III, Stenvik & Thayer, 2004; Leti & Bricout, 2013). Thus, HRV may be a good indicator to assess the athlete's adaptation process to the training sessions (Moreno, Parrado & Capdevila, 2013).

The purpose of this study is to analyse the effect of acute physical exercise on the mood and modulation of the autonomous nervous system by analysing HRV in young people, both active and non-active, through a stress test at an intensity of 80% of HR_{max} in controlled laboratory conditions.

MATERIALS AND METHOD

Participants

The sample of this study was made up of a total of 30 university students (14 women and 16 men) with an average age of 19.22 ± 1.65 years, an average height of 1.71 ± 0.11cm and an average weight of 66.23 ±11.88 Kg. They all participated voluntarily with informed consent. The study was approved by the university's ethics committee.

Instruments

The following instruments were used in this study:

- Physical Activity Readiness Questionnaire (PAR-Q, Thomas, Reading & Shephard, 1992). This is a seven-item questionnaire with dichotomous responses (yes/no) to eliminate participants with possible heart disorders from the study. If the participant answered affirmatively to even one item (such as *suffering from a heart disease, chest pain, loss of balance due to dizziness, problems with bones or joints*), they were regarded as unsuitable for performing physical activity without previously being checked by a physician. The individuals had to respond negatively to all the items as a criterion for inclusion in this study.

- Self-Report on Stages of Change when Practising Physical Exercise (*Autoinforme de los Estadios de Cambio para la práctica de Ejercicio Físico*, AECEF; Capdevila, 2005). This evaluates the behaviour of practising physical exercised based on the classification of people into five stages of change following the model by Prochaska and DiClemente (1982): *precontemplation, contemplation, preparation for action, action* and *maintenance*.

- Profile of Mood States (POMS; McNair, Lorr and Droppelman, 1971). We used a short version with 15 items grouped into five mood factors: Tension, Depression, Hostility, Vigour and Fatigue (Fuentes, Balaguer, Meliá & Garcia-Meritá, 1995). The Vigour factor is the only that interpreted positively, with a higher score corresponding to a better mood. The remaining factors have a negative interpretation, and high scores are interpreted as a negative mood. The 15 items are preceded by the phrase: "How do you feel when…" and the answer range is a 10-point scale in which 0 is "*nothing*", 3 is "*a bit*", 7 is "*quite a bit*" and 10 is "*a lot*". The total POMS score was also calculated to assess the overall mood changes. This score results from subtracting the score on the Vigour factor from all the negative factors. The higher the total score, the higher the change in mood. Negative values in this total score are synonymous with a positive mood.

- HRV (heart rate variability) Test. The heart rate was recorded for 5 minutes in a supine position, at rest and with a free breathing pattern. The data were obtained via a Polar T31 thoracic band (Polar Electro brand) which sent the data to a computer with our own software created in the LabVIEW environment. Natural breathing was measured using a *SleepSense* band, which enabled us to record the participant's respiration cycles. To analyse the HRV, we calculated the following parameters in the time domain: the mean of the RR intervals (RRmean), the standard deviation of all the RR intervals (SDRR), the root mean square of differences of successive RR intervals (RMSSD) and the percentage of successive interval differences larger than 50 msec. computed over the entire recording (pNN50). The frequency domain parameters were obtained based on the fast Fourier transformation (FFT) to quantify the high-frequency bands (HF, 0.15-0.40 Hz), low-frequency bands (LF, 0.04-0.15 Hz), very low frequency bands (VLF, 0.00-0.04 Hz), the proportion of high and low frequencies (LF/HF), the percentage of high frequencies (%HF), the percentage of low frequencies (%LF) and the percentage of very low frequencies (%VLF).

- UKK (Urho Kaleka Kekkonen) 2-km Walk Test (Oja, Laukkanen, Pasanen, Tyry & Vuori, 1991). This is a submaximal stress test in which participants have to walk for 2 km as quickly as possible (without running) on a treadmill (Powerjog brand). Their physical condition is assessed through the UKK index (Oja, Laukkanen, Pasanen & Vuori, 1989), which is calculated based on the age, weight, height, time spent on the test and mean HR through the test of the heart frequency values measured at the following points: at 500 m (HR_{500}), at 1,000 m, (HR_{1000}), at 1,500 m (HR_{1500}) and at 2,000 m (HR_{2000}). To register the HR, the participants wore a Polar H7 thoracic band connected by Bluetooth to an iPad table (Apple brand), where a customised software programme instantaneously recorded participants' HR during exercise.

PROCEDURE

The participants in this study went to a laboratory to conduct physical fitness tests in a controlled setting. They were asked to participate in a single session lasting approximately 1.5 hour. Before coming to the session, the participants were asked to avoid performing intense physical activity, consuming drinks with alcohol or caffeine, ingesting non-essential medication in the 24 hours prior to the session, smoking or eating a heavy meal during the 3 hours prior to the session. They were also asked to have slept at least six hours the previous night.

After signing the informed consent form and eliminating any possible contraindications to performing the stress test based on the PAR-Q questionnaire, the AECEF and POMS questionnaires were administered. Once they were filled out but before the stress test, the HRV test was performed in which the RR intervals were recorded for 5 minutes with free breathing and the participant in a supine position. To record the HRV, dim lighting was used and the room temperature was between 19-23º C. The participants then did a two-minute warm-up on the treadmill and immediately afterward the UKK physical fitness test. A supervisor controlled the intensity of the test so that the participant reached 80% of HR_{max} calculated using Karvonen's formula, and so that the heart rate remained at 80% for the entire test. At the end, the participants once again filled out the POMS and then the post-test HRV was registered again following the same guidelines as for the pre-test assessment.

Data analysis

A multivariate analysis of variance (MANOVA) was applied following a general linear model to analyse the interaction between the level of physical exercise (Active/Non-active) and the possible pre/post-exercise change in the POMS. Given that the interaction was not significant, we performed a one-way analysis of variance to analyse the simple effects in terms of records during the effort. To analyse the differences between the pre- and post-exercise for the POMS, we applied a repeated measures analysis of variance. To perform this analysis, we used the SPSS statistics package (IBM SPSS Statistics, v. 21). We applied the Kolmogorov-Smirnov test and checked that all the quantitative variables studied fit a normal distribution.

To determine whether there were individual differences with regard to the practice of physical exercise, we classified the participants into two groups: *Active* and *Non-active*, depending on the results of the AECEF questionnaire. The participants who were in the precontemplation, contemplation and preparation for action stages were classified as *Non-active* participants, while those who were in the action and maintenance stages were classified as *Active* participants. We used one-way analysis of variance to analyse the differences between *Active* and *Non-active* participants, noting the homogeneity of the variances in all cases.

RESULTS

Regarding the classification of the participants according to their level of physical exercise according to the AECEF, 63.3% were *Non-active* and the remaining 36.7% were *Active*. The results of the UKK physical fitness test showed a significant difference in performance between the *Active* and *Non-active* participants, with the former showing higher performance compared to the latter ($p<0.05$).

Variables recorded in the stress test

Figure 1 shows the evolution in the heart rate of *Active* and *Non-active* participants as recorded during the UKK physical fitness test. According to one-way analysis of variance, the *Active* participants showed lower values compared to the *Non-active* participants for the variables RHR ($p=0.002$), HRs ($p=0.014$), HR_{500}($p=0.044$), HR_{1000}($p=0.023$), HR_{1500} ($p=0.006$) and HR_{2000} ($p=0.004$).

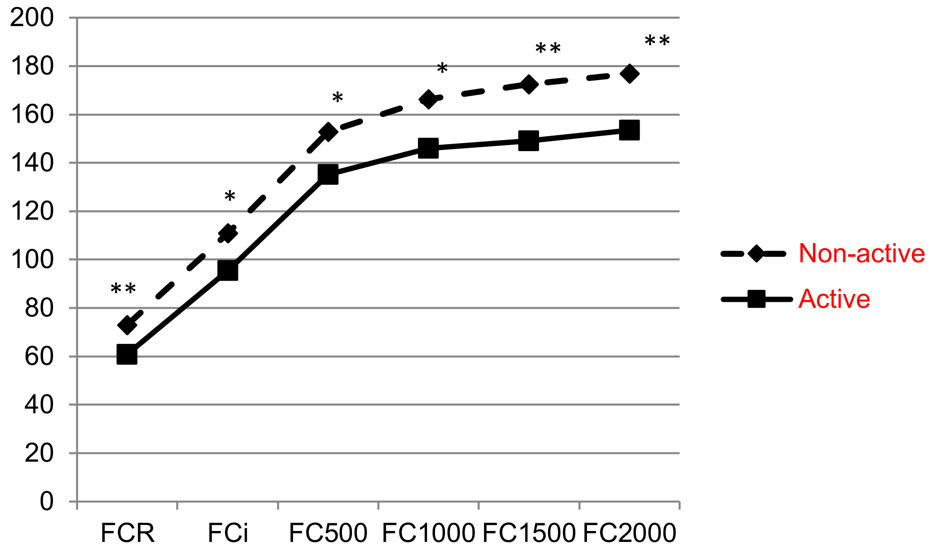

Figure 1. Evolution in the heart rate of the *Active* and *Non-active* participants throughout the physical fitness test (RHR: Resting Heart Rate; HRs: Heart rate at the start of the test; HR_{500}: Heart rate at 500 m, HR_{1000}: Heart rate at 1000 m, HR_{1500}: Heart rate at 1500 m, HR_{2000}: Heart rate at 2000 m). Significant differences between *Active* and *Non-active* * p<0.05. ** p<0.01.

Mood and level of physical exercise

Table 1 shows the average scores of the factors or moods on the POMS. By analysing the differences between pre- and post-exercise, we can see that the Depression factor is the only one which differs significantly between *Active* and *Non-active* participants (p=0.003). Figure 2 shows how the average pre-exercise level of Depression among *Active* participants is higher than among *Non-active* participants, and how with physical exercise this level drops more dramatically for the *Active* group, such that their post-exercise level of Depression is lower than that of the *Non-active* group. Likewise, we can see a significant post-exercise rise for the entire sample in the Vigour factor (p=0.030) and in the Fatigue factor (p=<0.001), while we can see a drop in the Tension factor (p=0.001). No significant change appeared in the Hostility factor.

Table 1. Average scores on mood evaluated with the POMS, pre- and post-exercise.

		PRE	POST	
Factors	**AECEF**	M (SD)	M (SD)	**p**
Vigour	Active	5.36 (2.63)	6.42 (2.06)	NS
	Non-active	4.03 (1.81)	4.87 (1.83)	
	Total	4.52 (2.20)	5.44 (2.03)	0.030
Fatigue	Active	1.81 (2.08)	3.72 (1.35)	NS
	Non-active	2.08 (2.16)	4.98 (2.21)	
	Total	1.98 (2.10)	4.52 (2.01)	<0.001
Tension	Active	1.39 (1.32)	0.90 (1.14)	NS
	Non-active	2.85 (2.15)	1.56 (1.96)	
	Total	2.32 (1.99)	1.32 (1.72)	0.001
Hostility	Active	0.21 (0.34)	0.18 (0.27)	NS
	Non-active	0.47 (1.14)	0.43 (1.02)	
	Total	0.37 (0.92)	0.34 (0.83)	NS
Depression	Active	1.36 (1.72)	0.57 (1.05)	0.003
	Non-active	0.96 (1.74)	0.70 (1.55)	
	Total	1.11 (1.71)	0.65 (1.37)	<0.001

Note. M=mean; SD=standard deviation; POMS=Profile of Mood States; PRE=pre-exercise; POST=post-exercise; p=level of significance (MANOVA); AECEF=Self-Report on States of Change when Practising Physical Exercise; NS= not significant.

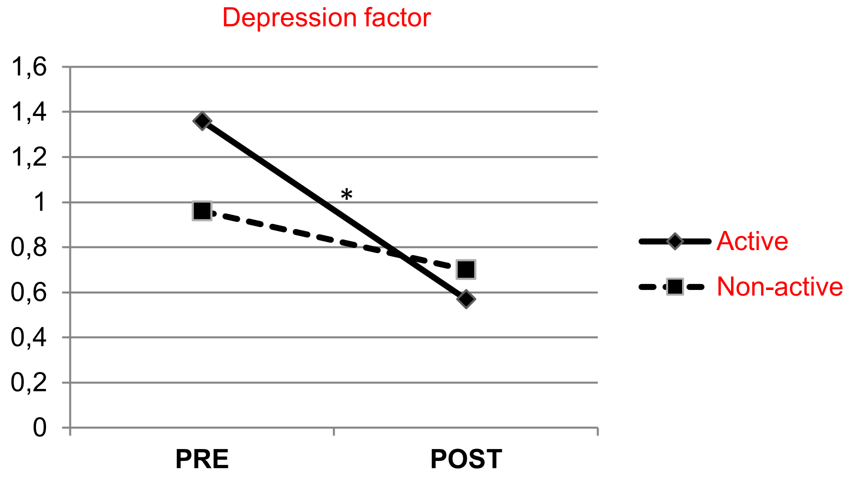

Figure 2. Scores on the Depression factor of the POMS for *Active* and *Non-active* participants. *p=0.003.

HRV and level of physical exercise

Table 2 shows the results from the analysis of the HRV pre- and post-exercise. In the parameters in the time domain, no significant differences were found between the *Active* and *Non-active* participants. The post-exercise values for the entire sample were significantly lower than the pre-exercise values for the parameters RRmean (p<0.001), SDNN (p<0.001) and RMSSD (p<0.001). In contrast, in the parameters in the frequency domain, we did observe significant differences between the *Active* and *Non-active* participants, namely LFnu2 ($p=0.05$) and HFnu2 ($p=0.05$), and for the entire sample between pre- and post-exercise ($p<0.001$). Finally, in the LF/HF parameter, we found a significant difference between pre- and post-exercise for the entire sample ($p<0.001$).

Table 2. Average score on the measurements of HRV, pre- and post-exercise.

		PRE	**POST**	
Means	**AECEF**	M (SD)	M (SD)	**p**
RR mean (ms)	Active	1005.97 (139.12)	799.49 (179.94)	NS
	Non- active	844.48 (105.04)	615.44 (76.14)	
	Total	902.15 (140.03)	681.17 (150.03)	<0.001
SDNN	Active	95.21 (58.72)	70.18 (52.05)	NS
	Non- active	71.87 (27.74)	27.99 (14.45)	
	Total	80.21 (41.99)	43.06 (38.19)	<0.001
RMSSD	Active	107.13 (74.26)	68.19 (71.65)	NS
	Non- active	69.34 (47.41)	14.79 (17.26)	
	Total	82.84 (59.95)	33.86 (50.77)	<0.001
LFnu2	Active	35.40 (15.77)	52.05 (25.16)	,05
	Non- active	37.79 (18.36)	67.98 (16.54)	
	Total	36.93 (17.22)	62.29 (21.06)	<0.001
HFnu2	Active	64.59 (15.77)	47.94 (25.16)	,05
	Non- active	62.20 (18.36)	32.01 (16.54)	
	Total	63.06 (17.22)	37.70 (21.06)	<0.001
LF/HF ratio	Active	0.65 (0.48)	1.94 (2.03)	NS
	Non- active	0.84 (0.97)	3.72 (3.79)	
	Total	0.77 (0.83)	3.08 (3.34)	0.001

Nota. M=mean; SD=standard deviation; RR mean= mean of RR intervals; SDNN= standard deviation of NN (or RR) periods; RMSSD= root mean square of differences of successive RR intervals; LFnu2= Low frequency; HFnu2= High frequency; LF/HF ratio=; PRE=pre-exercise; POS=post-exercise; p=significance; AECEF= Self-Report on States of Change when Practising Physical Exercise; NS= not significant.

DISCUSSION AND CONCLUSIONS

In this study, we have shown the beneficial effects of physical exercise on mood in line with previous studies (Biddle, Fox & Boutcher, 2000; Jiménez, Martínez, Miró & Sánchez, 2008; Torres, G., Torres, L., Zagalaz & Villaverde, 2010; Anderson & Brice, 2011; León-Prados, Calvo-Lluch & Ramos-Casado, 2012; Reigal & Videra, 2013), with the further result that these effects can occur with just a single brief session of physical exercise in both *Active* and *Non-active* people. Specifically, this study shows the acute effect of physical exercise on mood and the modulation of the autonomous nervous system through HRV analysis.

Numerous authors have reported the importance of specifying the characteristics of the type of physical exercise performed in studies, as well as its intensity, frequency and duration, so that the study is clearly delimited and the results are objective, since not all types of physical exercise have the same results or consequences on people's mood (Jiménez, Martínez, Miró & Sánchez, 2008; Reigal, Márquez, Videra, Martín & Juárez, 2013). For this reason, we controlled the heart rate (HR) of all the participants as they performed the physical fitness test in order to have evidence that they were all performing it at the same intensity level (80% of HR_{max}). In this way, the *Active* and *Non-active* participants performed the physical exercise with the same relative intensity and the results can be evaluated objectively. The results were what we expected, namely that HR values are always lower in the *Active* participants (Figure 1). This difference is due to their physical training; since they are used to performing physical exercise, their metabolism is more effective and so they were able to perform the stress test with a lower HR than the *Active* participants.

We assessed the scores on the POMS factors pre- and post-exercise for the sample as a whole, and according to the participants' level of physical exercise. We noted a significant rise in the post-exercise moods Vigour and Fatigue, and a drop in Tension and Depression for the entire sample, thus corroborating the results of other studies which found similar significant changes (Hansen et al., 2001; Anderson & Brice, 2011; Reigal et al., 2013; Reigal & Videra, 2013). However, there were no significant effects for Hostility, unlike in other previous studies where there was a drop in this factor post-exercise (Reigal & Videra, 2013). In our study, this result would have been very difficult because our participants scored under 1 on Hostility pre-exercise. What is more, we noted a significant difference in the Depression factor depending on the participants' level of exercise, since post-exercise the *Active* participants showed a considerably more pronounced drop in Depression than the *Non-active* participants. The drop in the Depression level post-exercise for the sample as a whole indicates that exercise has a positive effect on mood in both *Active* and *Non-active* participants, although this effect was more pronounced in the *Active* participants. This effect might be explained by the rise in the levels of neurotransmitters like norepinephrine, serotonin and dopamine, whose effects are related to improved moods (Herrera, 2008), or by the stimulation of the pituitary gland, which produces endorphins, leading to a sense of wellbeing as well as euphoria, the reason they are called the "happiness hormones" (Gutiérrez, Espino, Palenzuela & Jiménez, 1997; Martinsen, 2004). It could also be due to more subjective causes that are based on the rise in blood flow to the brain and increased body temperature, with tranquilising or evasive effects caused during exercise (Arruza et al., 2008). These mechanisms have a high degree of synergy and can occur at the same time since they are not mutually exclusive (Morgan, 1985). In the *Active* participants, we noted a greater decrease in the Depression factor. In the pre-exercise score, these participants started with higher levels of Depression than the *Non-active* participants, while post-exercise they scored lower than their *Non-active* counterparts, thus showing a higher degree of change. This difference may be due to the fact that in the *Active* participants, who are more used to performing physical exercise, this exercise produces a higher level of beta-endorphins (an opiate-like substance produced by the body) when they exceed the critical threshold of effort in which the production of lactate exceeds their metabolism; that is, the effect of training may be related to a rise in the level of beta-endorphins (Bohórquez, 2012).

The influence of aerobic physical activity in the long term and the aerobic capacity in HRV has been reported repeatedly in younger and older adults (Albinet, Boucard, Bouquet & Audiffren, 2012). In this study, we noted a post-exercise drop in all the parameters: RRmean, SDNN, RMSSD, LFnu2 and HFnu2, and a rise in the LF/HF ratio. What is more, we found significant differences between the *Active* and *Non-active* participants in the LFnu2 and HFnu2 parameters. The *Active* participants showed higher post-exercise HFnu2 values than the *Non-active* participants, indicating parasympathetic predominance in the former, since the physical fitness test had a lower impact on their body because they are used to performing physical exercise. This is in line with the idea that exercise alters the autonomous balance towards a parasympathetic predominance (Sakuragi & Sugiyama, 2006). In contrast, for the parameter LFnu2, which reflects the activity of the sympathetic system, there was a higher post-exercise increase in the *Non-active* participants. Thus, we can state that HRV analysis is a useful instrument for assessing people's adaptation to training.

In this study, we used a rigorous methodology to assess the acute effects of physical exercise on mood in both *Active* and *Non-active* participants. Unlike other studies, we controlled the fact that all the participants performed physical exercise of the same intensity, thus showing that such a simple, accessible activity as walking for a short time leads to psychological benefits in both sedentary and active people. These results have major implications on prescribing physical exercise, since a lack of time is often cited as the main barrier to performing physical exercise among sedentary people. Thus, participating in several short walking sessions daily could give rise to greater adherence to exercise than prescriptions for a single longer session (Focht, 2013).

Therefore, we conclude that performing acute physical exercise improves the mood of both *Active* and *Non-active* people, albeit more significantly in *Active* people. It also improves heart rate variability as an indication of a better ANS balance. However, we believe that it would be interesting to further pursue this avenue of inquiry by analysing different populations bearing in mind gender and level of physical exercise (*Active* and *Non-active*). By doing so, we could determine the characteristics of physical exercise (type, frequency, duration and intensity) that may be more appealing to sedentary people and thus offer simple yet effective ways for them to adopt an active, healthy lifestyle.

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