Original Article

Psycho-physiological changes after a half marathon in amateur runners

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Abstract

Of course, there is a strong link between mental health, active life, and street runners. In this sense, running at different distances and intensities can alter the anxiety, stress, and mood of runners. The aim of this study was to verify the psychophysiological changes in amateur runners after a half marathon. Cross-sectional study with twenty-two runners (34 ± 4.50 years old; 1.76 ± 0.06 m average height; 73.3 ± 8.19 kg weight) who participated in a 105-minute half-marathon, intensity higher than 80% of maximum VO₂, accumulated altimetry of 98 m, temperature of 23° C, and relative air humidity in 48%. Physiological analyzes (heart rate, running pace, and energy expenditure), strength tests (hand, shoulder, and lumbar waist), and mental health assessments (stress, anxiety, self-esteem, and happiness) before and immediately after the half-marathon race. Data were expressed as mean and standard error and statistically analyzed by unidirectional variance analysis (ANOVA), followed by Bonferroni's post-hoc test. The established significance level for the statistical test is $p < 0.05$. Regarding the results after the half-marathon, there was an important increase in HR average (146%), caloric expenditure (1.496 ± 252.19 kcal), of decrease ($p \leq 0.05$) of lumbar strength (30%); increased muscle pain (71%), perception of effort (76%), self-esteem (40%), and feeling of happiness (25%). In conclusion, we point out that a 21-km race training in amateur runners had an intense physiological load and a moderate psychological load, resulting in muscular physical waste, proven by the reduction in lumbar strength and moderate increases in sensations of pain and perceived effort. As a practical application, we suggest that a half marathon training is capable of increasing the happiness and self-esteem of runners, opening future doors for prevention or treatment of mental health disorders, quite frequent in our society.

Keywords: - Mental health, street running, endurance training, muscle strength.

Introduction

A half-marathon is a 21-km race of high energy expenditure (Gómez-Molina et al., 2017). According to Chen et al. (2017), academically, a half-marathon can be defined as a predominantly aerobic exercise of long duration, as it involves rhythmic movements sustained by large muscle groups, which require participation of the oxidative metabolism for energy supply.

Due to health benefits, low cost, and easy practice, race has become popular (Greco et al., 2018). Based on this, studies point out that background races involving distances of 5 km, 10 km, and half marathons have obtained in recent years an annual growth of 25%, becoming one of the most practiced exercises by amateurs in Brazil and the world (Balbinotti et al., 2015; Gómez-Molina et al., 2017; Hernando et al., 2020).

Evidently, there is a strong link between mental health, active life, and street corridors (Nikolaidis et al., 2019; Ohrnberger et al., 2017). Therefore, aerobic exercises at different intensities have positive effects on anxiety, stress, and affective and mood disorders of exercised people (Codella et al., 2017; Mikkelsen et al., 2017). Crush et al. (2018) and Schmitt et al. (2019) aerobic exercises involving racing, using different timing and intensities were compared, and it was found that a single session can relieve psychological burden in healthy people. However, excessive physical exercise can negatively affect the physical and mental health of individuals (Chang et al., 2020; Kruk et al., 2020; Mikkelsen et al., 2017).

According to the Pan American Health Organization (2018), mental health disorders are some of the most important causes of disability and mortality in South America. In particular, anxiety and stress disorders are

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the second leading cause of disability in the region, led by Brazil with 7.5%. In this sense, mental health disorders are associated with reduced happiness and self-esteem, which are frequent in today's society, contributing to 70% of mental diseases causes.

Based on these assumptions, the objective of this study was to investigate the acute response of a 21-km training on mental and physical health parameters of amateur runners. We hypothesized that a half-marathon training could reduce stress and anxiety, increase self-esteem and happiness, and decrease the muscle strength of amateur runners.

Material & methods

Characterization of the study

A descriptive and quantitative cross-sectional study of 22 amateur street runners in the Criciúma city, Santa Catarina, Brazil, conducted in April 2019. The runners participated in a 21-km street race (accumulated altimetry of 98 m, temperature of 23°C, and relative air humidity of 48%) in the morning. Strength tests (hand, shoulder, and lumbar waist) were applied to muscle and mental health assessments (stress, anxiety, self-esteem, and happiness) before and immediately after the half-marathon race.

Randomization of the study

The criterion used for sample selection was a non-probabilistic convenience (Silva et al. 2019) using inclusion and exclusion criteria. From a group of 20 amateur street runners (running for 18 months), 22 adults used to running long distances (between 35 and 42Km per week) were randomized and allocated to a single group, using as inclusion criteria to be older than 20, trained for more than 1 year and taking part in, at least, one 21-km race in the street running mode. Exclusion criteria were to have suffered some joint muscle injury in the previous 3 months, or have never completed 21-km running, or have never performed a half-marathon in less than 150 minutes.

Sample Characterization

Sample consisted of 22 adult runners (34±4 years; 1.76±5m; 73±8kg): 20 male and 2 female. The nutritional state of the runners was calculated by the index of corporal mass (IMC) (WHO, 1995) using self-reported corporal weight and stature. The runners with BMI <25Kg/m² were classified as "not overweight" and those with BMI ≥25Kg/m² as "overweight" (Table 1). All runners were regularly trained in the same race group at least 12 months 3–5 times a week, 35–42 km per week.

21-km Race Training

The 21-km street race was held in the morning, with accumulated altimetry of 98 m, temperature of 23°C, and relative humidity in the air at 48% through the Centennial Avenue of Criciúma City. All runners were told to complete the 21 km in a moderate to high intensity (>80% of the Heart Rate of training, 5–7 points on the adapted Borg scale (Borg, 1982).

Analysis and data collection

All the runners selected in the sample knew about the tests, inventories, subjective scales, and the route of the race (location, time, intensity, distance, optional hydration points) 1 week before the race. On the race day, 45 minutes before the start of the race, the clocks (which had GPS) were updated, applied exactly in this order the inventories, subjective scales, and tests with force dynamometers. Five minutes after the end of the race, respecting the order of arriving, the same inventories, scales, and force tests were applied, in this sequence. Information from the clocks was the last to be collected.

Physiological control variables

All runners were equipped with individually updated Garmin brand watches with anthropometric information to collect the control variables: resting heart rate (HR_r), maximum heart rate (HR_{max}), final heart rate (FC_f), average heart rate (HR_m), running pace (pace in minutes per kilometer (m/km) and speed in kilometers per hour (Km/h)), caloric expenditure, and finally running time (Table 2).

Force parameters

A Jamar hand pressure dynamometer was used to quantify the force in both hands of the runners, according to the guidelines of the American Society of Hand Therapists (Moreira et al., 2003). Each runner sat with his shoulder abducted and elbow flexed 90°, with the forearm in a neutral position and the wrist extended between 0° and 30°. The second dynamometer used was the lumbar traction dynamometer to quantify the force at this location. The aisles were oriented one at a time to stand on the dynamometer platform with the knees and torso slightly bent, and the dynamometer handle was adjusted at the height of the apex of the patella so that the evaluator could hold it with both hands and elbows extended (Guedes & Guedes, 2006). Finally, the 100-kgf analog scapular dynamometer was used to quantify the traction of the scapular waist of the corridors. The

evaluators were oriented in the orthostatic position, shoulders abducted, elbows flexed, forearms in the neutral position, and thumbs extended (Guedes & Guedes, 2006).

Mental health inventories and subjective scales.

The State of Competitive Anxiety Inventory (CASI-2) was applied (Pons et al., 2018), with 17 questions with four possible answers: 1—Nothing, 2—A little, 3—Moderate, 4—Very; the maximum result being 68 points. For quantification of anxiety, the results of points are added. For the stress levels, the inventory of stress symptoms for adults (ISSL) was adapted (Lipp, 2000). To evaluate acute somatic and psychological indicators, the first two phases (alert, resistance) were used. Regarding the subjective scales, the Borg effort (Borg, 1982), pain (Visual Analogue Scale – VAS) (Barbosa et al., 2015), and adapted to the self-esteem scale and happiness scale were applied. These instruments (esteem and happiness scale) subjectively evaluate sensations using a continuous line ranging from zero (low sensation) to ten (high sensation), with the same characteristics as the pain and Borg scales.

Statistical analysis

The data were expressed as mean and standard error and statistically analyzed by one-way analysis of variance (ANOVA), followed by the Bonferroni post hoc test. The established significance level for the statistical test is $p < 0.05$. The SPSS (Statistical Package for the Social Sciences) version 20.0 was used as the statistical package.

Ethical considerations

This study was conducted in accordance with Resolution 466/12 of the National Health Council (CNS) and approved by the Ethics Committee of the University of Extremo Sul Catarinense with the CAAE protocol: 18982719.1.0000.0119. All participants signed the informed consent form.

Results

From a group of 200 runners, 138 athletes were not excluded for not having participated in at least one race of 21 km, 36 runners for not having 1 year of training in the sport and 4 for joint muscle injury. In total, 22 street runners were analyzed (Fig. 1).

Figure 1. Flowchart of the randomization process.

It was identified that the majority was male (91%), that all were adults (age 34 ± 4.50) and not overweight (BMI 23.75 ± 2.37 ; body weight $73.3 \text{ kg} \pm 8.19$; height 1.76 ± 0.06) (Table 1).

Table 1. Characterization of the sample

Age	Stature (meters)	Body Weight (Kg)	BMI	Male Gender	Female Gender
34 ± 4.50	1.76 ± 0.06	73.3 ± 8.19	23.75 ± 2.37	20	2

Note: BMI: body mass index; Kg: kilograms.

Regarding the physiological parameters, Table 2 shows that in the average of the group the run took place in high intensity (92% HRmax; representing 81% of VO2max) with a significant increase in HR average (146%) and final (120%) in relation to HR at rest ($69 \pm 14 \text{ bpm}$) respectively ($p \leq 0.05$). The runners completed the 21km with an average time of $105 \pm 10.93 \text{ min}$, the average pace was $4.53 \pm 0.51 \text{ m/km}$, and average speed of $12.26 \pm 1.10 \text{ km/h}$. Finally, the average caloric outcome of the race was $1.496 \pm 252.19 \text{ kcal}$.

Table 2. Physiological control variables in street corridors of Criciúma, Santa Catarina, Brazil, 2019

HR rest (bpm)	HR maximum (bpm)	HR final (bpm)	HR average (bpm)	RITMO: a) Pace (m/km) b) Speed (Km/h)	TIME (minutes)	ENERGY DISPENDITION (Kcal)
69 ± 14.97	*184 ± 2.74	*152 ± 20.46	*170 ± 18.74	a) 4.53 ± 0.51 b) 12.26 ± 1.10	105 ± 10.93	1496 ± 252.19

Note: HR: heart rate; bpm: beat per minute; Kcal: kilocalories; m/km: minutes per kilometers; Km/h: kilometers per hour. Bonferroni post hoc test. *Level of significance was $p < 0.05$ in relation to HR rest.

The results of muscle strength (Fig. 2) point to a significant decrease (30%) after 21 km of strength in the lumbar region, while for the scapular and manual waist strength, there was no significant difference after running (scapular waist $p = 0.087$; right hand $p = 0.091$; left hand $p = 0.084$).

Figure 2. Force tests with dynamometers in adult 21-km runners. *Level of significance was $p < 0.05$ in relation to after 21 km.

Regarding mental health (Fig. 3), the results expressed a significant increase ($p \leq 0.05$) in all subjective scales, pain 71%, effort 76%, self-esteem 40%, and happiness 25%, and no significant difference in stress and anxiety scores ($p > 0.05$) was observed.

Figure 3. Mental health inventories and subjective scales in adult 21-km runners. *Level of significance was $p < 0.05$ in relation to after 21 km.

Discussion

Physical exercise, especially aerobics, has improved mental and muscular health in different populations (Castanhel et al., 2019; Chen et al., 2017; Mikkelsen et al., 2017; Silva et al., 2019). Specifically, race has an anxiolytic, anti-stress, and psychological well-being effect (Chen et al., 2017). The results of this

study show that a 21-km race signals high physiological load, causing muscle waste, along with psychological changes expressed by increases in pain, effort, self-esteem, and happiness.

For decades, the literature has used CF as one of the variables to determine the physiological intensity of exercise (Karvonen & Vuorimaa, 1988; Samendinger et al., 2019). The present study observed (table 2) that during the race, HR worked on average 92% of its maximum capacity, which corresponds to a high intensity exercise, above the lactate threshold (Gómez-Molina et al., 2017; Hernando et al., 2020). In this sense, Wiewelhove et al. (2018) after a test found that 45 half amateur marathon run in a time of 112 min at an average intensity of 90.2 ± 7.4 % of the anaerobic threshold with a perception of effort of 7.2 ± 1.7 points (scale from zero to ten points). We note that the runners completed the half-marathon with an average time of 1 h 45 min, with a very close rhythm of competition suggested by Sánchez et al. (2014), of approximately 13km/h.

In relation to muscle waste, we quantify the changes in muscle strength (hands, scapular waist, and lumbar) that are directly related to muscle health. The results obtained in Figure 1 indicate a 30% decrease in lumbar strength after running, without significant changes in hand and scapular waist strength. It is a fact that low levels of muscle strength negatively affect the physical and consequently mental performance of athletes, even if they are amateurs (Aubry et al., 2015; Coutts et al., 2007). In contrast, adequate levels of muscle strength allow for more efficient specific movements with less psychophysiological stress (ACSM, 2017). We believe that a possible explanation for the decrease in muscle strength after running only affects the lumbar muscles corresponds to the peripheral fatigue of the repetitive effort exercised at this location, biomechanically characteristic of a half-marathon run.

Regarding the psychological parameters of pain and effort, our results indicate a quantitative increase of 71% and 76%, respectively ($p \leq 0.05$) after the test, being qualitatively classified as moderate exercise intensity, according to Barbosa et al. (2015) and Borg (1982). In this sense the subjective scales have been used effectively to establish physical training intensities (De Lima Costa et al., 2020; Borsoi et al., 2019; Tang et al., 2016). According to these results, we suggested that the mental load (pain and effort) verified, allowed the runners to tolerate a significant physiological load (table 2). A psychophysiological explanation for this finding is possibly related to the fact that affective changes occur by a positive cognitive evaluation of the physical exercise satisfactorily completed, which consequently reinforces confidence in the psychophysical abilities of the runners (Mikkelsen et al., 2017; Rudolph & McAuley, 1996). According to Rudolph and MacAuley (1996), increases in self-efficacy after exercise make individuals tolerate perceived effort, which agrees with the results of this study.

Specifically, in relation to the mental health parameters investigated in this study, the perception of self-esteem and happiness was evaluated. Several studies point to improvements in several aspects of mental health, such as: self-esteem, humor, happiness, and well-being (Crush et al., 2018; Mikkelsen et al., 2017; Schmid et al., 2007; Skead & Rogers, 2016) in chronically exercised individuals. However, little is known about the acute effect of a half-marathon training in non-athletes. Our results show an increase in the perception of self-esteem and happiness of 40% and 25%, respectively, immediately after 21 km. According to Mikkelsen et al. (2017), physical exercise (running) activates mechanisms (neogenesis, angiogenesis, and neuroplasticity) that consequently synthesize neurotransmitters responsible for the mental health benefits of healthy individuals. Acutely, aerobic exercise increases the levels of noradrenaline and serotonin. These neurotransmitters contribute to improve mood (Mikkelsen et al., 2017; Ohrnberger et al., 2017), altering self-esteem and happiness positively. Physiologically, endorphin—a hormone neurotransmitter released by the anterior pituitary gland—, soon after the 21-km race, may have contributed to disguise the sensations of pain and effort. However, this requires further studies.

Finally, according to our results, we pointed out that the perceived levels of stress and anxiety were not altered after the half marathon training. One possible explanation for this finding is that in this situation (training), individuals are comfortable, without stress and mental anxiety. This was observed in the pre-test values of the present study (fig. 3). However, another study, such as Follador et al. (2018), states that intense exercising can be stressful and generate displeasure. It did not occur in our half marathon training. Other authors like Benedetti et al., (2012), who studied stress levels in amateur marathon runners, state that physical exercise benefits the mental health of runners. Studies conducted in our laboratory (Silva et al., 2019) proved that moderate intensity aerobic exercise decreases levels of anxiety and stress. Therefore, the literature is still confusing and needs more studies. We highlight that factors such as intensity, duration, and environment (aquatic or terrestrial) have affected differently the levels of stress and anxiety in different people.

Conclusions

We point out that a 21-km race training in amateur runners had an intense physiological load and a moderate psychological load, resulting in muscular physical waste, proven by the reduction in lumbar strength and moderate increases in sensations of pain and perceived effort. As a practical application, we suggest that a half marathon training is capable of increasing the happiness and self-esteem of runners, opening future doors for prevention or treatment of mental health disorders, quite frequent in our society.

As a limitation, we point out the non-quantification of lower limb muscle waste and analysis of biochemical markers related to mental health. Future studies are recommended.

Conflicts of interest - The authors have no conflict of interest to declare.

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