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Exergames reduces triceps and subscapular skinfolds and improve self-esteem and body image of obese children

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Abstract
Exergames appear to be an interesting tool for practicing physical activity with obese or overweight children. The objective of this study was to verify the effects of a physical exercise program with *exergames* on the self-esteem, body image and anthropometry of overweight or obese children. Forty-two children aged 6 to 11 years obese and/or overweight, were divided into two groups: E*xergames* group (GE) and Control group (GC). The exercise program with *exergames* was performed twice a week, on alternate days for 12 weeks. Regarding the results, although it was not possible to identify statistically significant differences in body mass values through the data analysis, significant differences were observed in skinfold values ($p \leq 0.01$). Significant differences were also observed in the positive affects of the GE and improvement in the results of image distortion and satisfaction ($p \leq 0.01$). The exercise program with *exergames* reduced triceps and subscapular skinfolds and improved self-esteem and body image of obese children.

Keywords: Exergames, pediatric obesity, self-steem, body image

Introduction
Nowadays, technology occupies all spaces and most people have started to use it frequently for the most diverse daily activities. Castells[1] point out that the use of new information technologies can integrate the world in a global way through computer-mediated communication.
On the other hand, within this technological culture, regarding free time, the literature warns that Brazilian adolescents spend many hours a day using these modern technologies - *tablets*, cell phones, games, television, etc. According to the Brazilian Institute of Geography and Statistics (IBGE), 28.9% of Brazilians spend at least three hours watching television every day [2].
In the United States, adolescents watch on average 22 hours of television per week. When computer games are added, adolescents spend between 35 and 55 hours per week involved in this type of activity. Although a broad set of data is not available, it is believed that the numbers in developing countries, such as Brazil, reveal similar behavior [3].
Devices such as *tablets*, computers, cell phones, and next generation games are part of the industrialization process. This phenomenon influences children in a cognitive, affective, and social way, since sedentarism is inherent in the process of automation generated by technology [4].
An investigation conducted by AVG Technologies in 2015 with families around the world showed that 66% of children between three and five years of age were able to use computer games, 47% knew how to use a *smartphone*, but only 14% tied their shoes alone. In the case of Brazilian children, the survey pointed out that 97% of children between six and nine years of age use the internet and 54% have a *Facebook* profile [5].
In today's world, the comfort brought by technology makes tasks easier, both physically and mentally, and people are more accustomed to this comfort, which can trigger

overweight or obesity, than the practice of physical exercise.
According to the World Health Organization (WHO), obesity and overweight have reached epidemic proportions worldwide, even being classified as the epidemic of the 21st century [6].
Currently, there are an estimated 43 million obese children worldwide, and this number continues to increase [7]. Excess weight has become an increasingly frequent concern since people are much more sedentary and consuming large amounts of high fat foods [8].
One in three children aged 5 to 9 years of age is over the weight recommended by the WHO, and 23.2% of adolescent present excess weight [9]. In addition, obese children are more prone to hypertension, diabetes, and cardiac, respiratory, and orthopedic disorders, and approximately 50% of them present alterations in cholesterol [10].
The dietary preferences of children, as well as physical activity practices are directly influenced by their parents' lifestyles, which often persist into adulthood, reinforcing the hypothesis that environmental factors are critical in maintaining healthy lifestyles [11].
Children who are physically active are more likely to become active adults, highlighting the point of view of public health and preventive medicine. The promotion of physical activity in childhood and adolescence means establishing a solid basis for reducing the prevalence of sedentarism in adulthood, thus contributing to a better quality of life [12].
Among the factors that make up the concept of quality of life, self-esteem stands out, since it affects the way in which the child sees and interprets themselves, their relationships, and the world around them. There is a correlation between self-esteem, school achievement, and social approval, and this correlation is generalizable to virtually all ethnic and cultural groups [13].
Adolescents with low self-esteem develop mechanisms that probably distort communication of their thoughts and feelings and hinder group integration [14]. This fact aids in understanding their difficulty in participating in physical group activities, a very common situation in this phase of life.
One easy access alternative for children with interaction difficulties is video games, as these individuals are prone to social isolation and avoiding physical group activities, so that their contact with the world is provided primarily through virtual means.
Within this line of reasoning, virtual game technologies, concerned with how these children and adolescents could become inactive, obese, and present low self-esteem in the future, have modernized and created the possibility within video games for players to use their own body on the move to play and have fun, that is, the game becomes physical activity practice in the form of leisure, so-called *exergames* [15].
In this sense, *exergames* appear as a very interesting tool to introduce the practice of physical activity into the daily life of obese or overweight and inactive children, as well as providing a safe and protected environment (through the virtual context) away from the threatening and harsh criticism that these children imagine they will receive, so that they can develop their physical and social skills and, consequently, their self-esteem.
In a systematic review LeBlanc *et al.* [16]. aimed to explain the relationship between *exergames* and nine health and behavioral indicators in children. The authors selected 51 studies related to the theme and reported that active games are associated with sharp increases in energy expenditure. In addition, the *exergames* stood out as promising, especially when used for learning and rehabilitation.
Andrade *et al.* [17]. verified that the practice of *exergames* produced significant psychological effects, such as increased self-esteem and stamina, and reduced depression, body dissatisfaction, and mental confusion of adolescents with obesity.
Exergaming offers new and exciting horizons to be explored by researchers and healthcare professionals engaged in the fight against childhood obesity. In this light, technology may be viewed as an effective strategy for the encouragement of active and healthy behaviors and as an aid in the fight against childhood obesity [18].
Exergaming technology appears to have a considerable potential in this aspect, encouraging positive behaviors. However, more discussion is needed on strategies employing attractive interventions to fight the growing problem of childhood obesity around the world [18].
Thus, the aim of this study was to verify the effects of a physical exercise program with *exergames* on the self-esteem, body image, and anthropometry of children, aged 6 to 11 years, classified as overweight or obese.

Materials and Method
Participants
In total, 42 children participated in this study, aged 6 to 11 years of age, both boys and girls, who were obese and/or overweight. The children were divided into two groups: *Exergames* Group (GE; n = 31), participants of the physical exercise program with *exergames*, and Control Group, children who only participated in physical education at school (GC; n=11).
The sample was selected on a voluntary basis, through the availability and acceptance of families and children to participate in the study. Participants were classified as overweight/obese according to the WHO criteria [6].
As inclusion criteria, children classified as overweight or obese were selected. As exclusion criteria the following were considered: children who presented a frequency lower than 90% in the exercise program with *exergames*; participated in another form of exercise program not proposed by the research; or who had a heart or musculoskeletal problem that could compromise their physical integrity.
The children were informed verbally and in writing, through the Informed Consent Form (signed by the parents or guardians) and the Informed Consent Form (signed by the children), regarding the procedures that would be adopted in the research.
The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki and it was approved by the Ethics Committee of the School of Physical Education and Sport of the University of Sao Paulo (n. 2.519.692).

Measures
An anthropometric evaluation was performed to determine the Body Mass Index (BMI) and triceps and subscapular skinfolds; evaluation of diet and physical activity through the Previous Day Food Questionnaire (QUADA) and the Previous Day Physical Activity Questionnaire (QUAFDA) [19, 20, 21] and body perception [22]; evaluation of self-esteem, through the scale of positive and negative affects of Laurent *et al.* [23].
All evaluations were applied at the beginning of the intervention (pre-test moment) and after 12 weeks (post-test moment).

Scale of positive and negative affects

To evaluate positive and negative affects, which is a measure of child well-being related to self-esteem, the version of the positive and negative affect scale was used [23].

The instruction given will be for the child to respond how they are feeling lately. The response options have a five-point Likert scale format, with the following gradations: "not at all", "a little", "more or less", "a lot" and "a lot".

Body Image Instrument - Children's Silhouettes Figures Scale

This instrument, constructed and validated for Brazilian children aged 7 to 12 years by Kakeshita [22], consists of 11 silhouettes of each sex, presented in individual cards with progressive variations in the scale of measurements, of the leaner figure (BMI = 12 kg / m^2) to the largest (BMI = 29 kg / m^2).

To evaluate the body image, the child is asked to answer three questions, namely: Choose the silhouette that is closest to the image you have of your own body at the moment. Results close to zero indicate an accurate perception; negative results indicate an underestimation of the body size while the positive ones indicate its overestimation.

Next, the child should indicate the silhouette they would like to have. Results equal to zero are indicators of satisfaction and positive or negative results indicate degrees of dissatisfaction, desiring larger or smaller silhouettes, respectively. The third and final question will be - which figure represents the body you think is ideal for children your age.

Dietary habits questionnaire and previous day physical activity questionnaire

The Prior Day Food Questionnaire and the Prior Day Physical Activity Questionnaire are indicated to evaluate, respectively, food behavior and physical activity of children from seven to ten years old. These are structured questionnaires based on the food choices and activities of children the day before [20].

Anthropometry

Children's anthropometric data were collected according to internationally accepted procedures. These procedures were performed in order to determine the Body Mass Index (BMI) and subscapular and tricipital skinfolds of the participants. The folds were measured three times (Cescorf adipometer), with the intermediate folding not exceeding 5% of the other two folds measured in the place recorded [24].

All procedures were performed by the same examiner.

Body Mass Index (BMI)

The Body Mass Index was obtained through the relationship between Height and Body Mass squared (Body Mass/ $Height^2$).

Height

For height assessment, a stadiometer with an accuracy of 0.1 cm was used (E150 A wall stadiometer). The subject placed the child upright, with feet together, heels, buttocks, back and back of the head in contact with the scale.

The measurement was performed from the soles of the feet to the cerebral vertex. The head was oriented to stay on the Frankfurt plane (auriculo-orbital plane).

Body Mass

The child stood upright, in the center of the platform of an electronic scale (Lucastec - Ple 180), with his back to the scale, and looking at a fixed point in front of him, in order to avoid fluctuations in reading. Every ten evaluations the scale was turned off and on again, according to the manufacturer's guidance.

Subscapular skinfolds

The child stood up, with his back to the researcher, with his shoulders erect and relaxed and with his arms at his sides. The thickness of the subscapular skinfold was obtained obliquely to the longitudinal axis, following the orientation of the ribs. The thickness of the fold was measured at two centimeters below the lower angle of the scapula.

Tricipital skinfolds

The child stood up, with his back to the researcher, with his right arm relaxed along his body. The thickness of the fold will be measured at the back of the arm, in the middle of the distance between the acromion and the olecranon and parallel to the longitudinal axis of the body.

Procedures

The physical exercise program with *exergames* was established from a pilot study and conducted by only one professional. The session lasted one hour, with 50 minutes representing the main part (physical exercises with the *exergames*) and the remaining 10 minutes for stretching. The intervention was performed twice a week, on alternate days, for 12 weeks. The classes were composed of a maximum of 10 kids per hour. They were divided into pairs for each video game console.

In the room where the intervention program was performed, there are five Xbox 360 consoles, equipped with motion sensor called Kinect. For each Xbox 360 console was placed a pre-established game (TV1 Adventure, TV2 Athletics, TV3 Just Dance, TV4 Boxing and TV5 free - where the child chooses the game to play). Each pair of children had to change the TV every 10 minutes. Thus, by the end of the session, all the kids have done the rotation of the TVs and played all the games.

Statistical Analysis

The comparisons between groups and moments, involving quantitative variables, were analyzed through the linear regression model with mixed effects (random and fixed effects). These models assume that the residual will have a normal distribution with a mean of 0 and constant σ^2 variance. In situations where this assumption was not observed, transformations in the response variable were used. For the comparisons, the orthogonal contrasts post-test was used.

The comparison between the groups and moments regarding the food groups of the Prior Day Food Questionnaire and the Prior Day Physical Activity Questionnaire (qualitative binary variables) was carried out through a logistic regression model with random effects belonging to the class of GEE models (*generalized estimating equations*).

The Prior Day Food Questionnaire was analyzed considering the response to each recommended food group. The Prior Day Physical Activity Questionnaire responses were categorized as very active/intermediate, and not very active.

The Effect Size (ES) was calculated using Cohen's method considering the standard deviation of the estimated difference.

Results

The main effects of the *exergames* program on BMI and triceps and subscapular skinfolds, observed in the exercise sessions with children, are shown in table 1.

Table 1: Mean and standard deviation values for the body composition, and triceps and subscapular skinfolds of children from the *exergames* program

	Pre	Post	Estimated difference between moments	p*	p**	p***
			GC (n=11)			
BMI	26.47 (3.32)	26.7 (3.12)	-0.22	0.47	0.64	0.98
Triceps	24.73 (2.97)	29 (4.65)	-4.27	<0.01*	0.35	<0.01
Subscapular	27.55 (7.23)	30.55 (7.16)	-3.00	0.03*	0.79	0.11
			GE (n=31)			
BMI	27.17 (4.08)	26.78 (4.0)	0.37	0.06		
Triceps	23.42 (4.07)	21.94 (3.44)	1.52	<0.01*		
Subscapular	28.32 (8.69)	26.06 (7.47)	2.22	<0.01*		

* Comparison between moments;
** Comparison between groups at the pre moment;
*** Comparison between groups at the post moment

Although it was not possible to identify statistically significant differences in the body mass index values (BMI), the triceps and subscapular cutaneous skinfolds values presented significant differences. In the GC, there was an increase in triceps skinfold thickness ($p< 0.01$; ES 1.44) and in the GE there was a decrease ($p< 0.01$; ES 0.51). Regarding subscapular skinfold thickness in the GC, a significant increase ($p\leq 0.01$; ES 0.70) was observed and in the GE a decrease ($p< 0.01$; ES 0.51), as demonstrated in table 1.
Regarding the comparisons between groups, no differences were observed at the pre-moment, however at the post-moment a difference in triceps skinfold was observed ($p< 0.01$; ES 0.81).
Regarding the GC values analyzed (pre x post) there were no significant differences in the results related to positive and negative affects (Table 2).

Table 2: Effects of *exergames* on positive and negative affects observed in children (n = 42) during the program.

	Pre	Post	Estimated difference between moments	p*	p**	p***
			GC (n=11)			
Positive	58.09 (13.25)	54.73 (11.34)	3.36	0.35	0.62	0.02
Negative	35.45 (18.25)	34.18 (13.47)	1.27	0.73	0.76	0.18
			GE (n=31)			
Positive	60.61 (11.82)	64.61 (10.99)	-4.45	0.04*		
Negative	34.06 (15.12)	27.68 (9.78)	6.31	<0.01*		

* Comparison between moments;
** Comparison between groups at the pre moment;
*** Comparison between groups at the post moment.

Regarding the analysis performed in the GE (pre x post), it was possible to observe a significant increase in the values referring to the positive affects ($p\leq 0.04$; ES 0.38) and a decrease in negative affects at the post test moment ($p< 0.01$; ES 0.52). Regarding the comparisons between groups, no differences were observed at the pre moment. However, at the post moment a significant difference (p=0.02; ES 0.37) was observed for positive affects.
Regarding the analyzed GC values (pre x post) there were no significant differences in the results of distortion and image satisfaction (Table 3).

Table 3: Effects of the *exergames* program on body image observed in the children (n=42).

		Pre	Post	Estimated difference between moments	p*	p**	p***
				Control Group (n=11)			
Distorted		-3.34 (4.07)	-3.88 (3.74)	0.53	0.48	0.86	0,83
Satisfied		6.49 (4.42)	7.11 (5.37)	0.62	0.45	0.29	0,31
				Exercise Group (n=31)			
Distorted		-3.65 (3.16)	-4.18 (3.31)	0.58	0.21		
Satisfied		-7.9 (3.36)	-5.76 (3.32)	-2.16	<0.01*		

* Comparison between moments;
** Comparison between groups at the pre moment;
*** Comparison between groups at the post moment.

On the other hand, when analyzing these same data in the GE it was possible to identify a significant difference for the satisfaction variable ($p< 0.01$; ES 0.80). No significant differences were found between the groups when comparing the two moments (pre and post).
With respect to the Prior Day Food Questionnaire values (Figure 1), no significant differences were observed in the eating habits of the children studied for either the GE or GC.

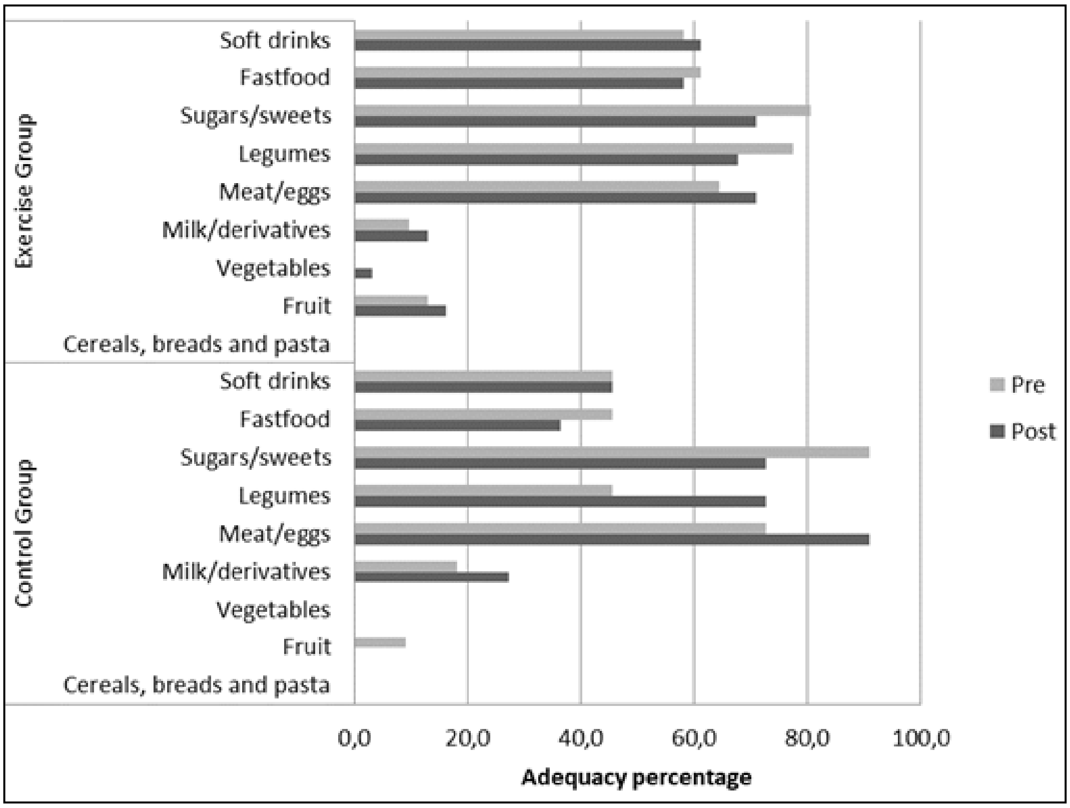

Fig 1: Effects of the *exergames* program on eating habits (Prior Day Food Questionnaire) observed in the children (n = 42).

Regarding the results of the levels of physical activity in the children of the control group and exercise group, through the Prior Day Physical Activity Questionnaire, no significant differences were found in the present study for either group (Figure 2).

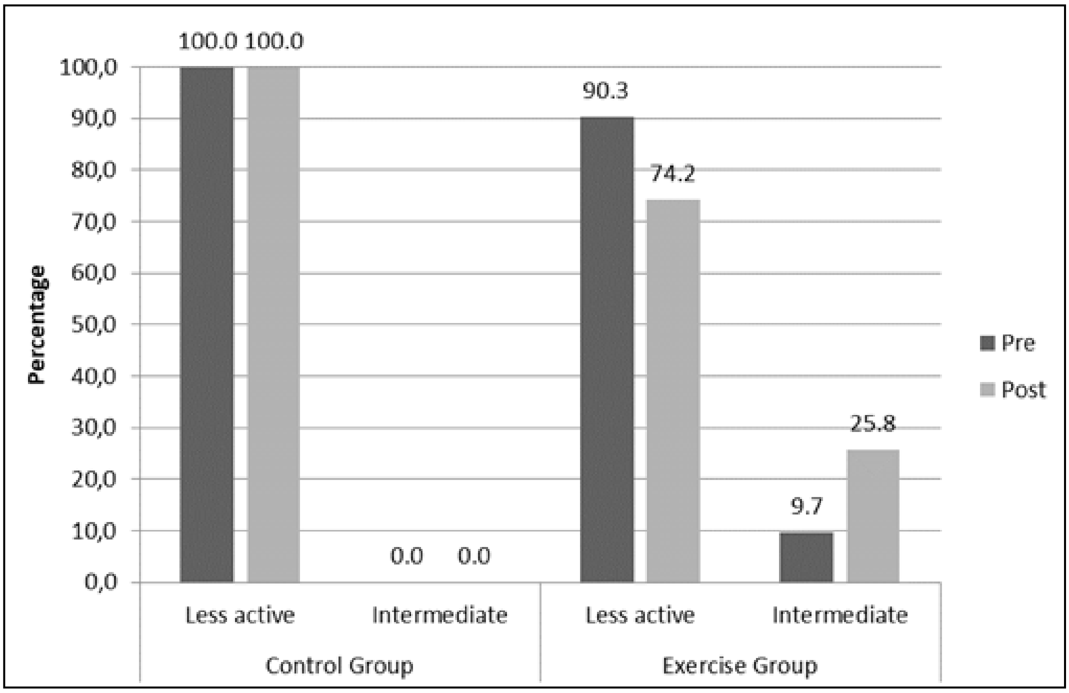

Fig 2: Effects of the *exergames* program on the level of physical activity (Prior Day Physical Activity Questionnaire) observed in the children (n = 42).

Discussion

In the present study, it was possible to verify that the use of *exergames* resulted a significant improvement in positive affects and a reduction in negative affects linked to the self-esteem and body image of children, besides increasing satisfaction with their body image. In the same way, the exercise practitioners also presented significant decreases in triceps and subscapular skinfolds.

Similar to the present study, Ogden *et al.* [25] also verified an improvement in self-esteem and image perception through the use of *exergames* in children with obesity.

Wagener, Fedele, Mignogna, Hester, & Gillaspy [26] conducted a study whose objective was to investigate the impact of dance-based *exergaming* on obese adolescents. In that study, the competence in the exercise, psychological data, and BMI were investigated. A sample of 40 obese adolescents was randomized to an *exergaming* program over a 10-week period. In the results, the authors identified that compared to controls, participants in the *exergaming* presented significantly increased perception of competence in the exercise and also reported significant improvement in psychological aspects as well as in relationships with parents from baseline to the end of the treatment.

However, no pre- to post-test differences were observed in BMI in the study by Wagener *et al.* [26], similar to the results found in the present study. The literature points to the fact that to demonstrate significant effects on BMI values, longer-term programs and more long-term evaluations may be necessary.[27]

Another study conducted in the United States examined whether a 20-week *exergame* program could produce weight loss and improve the psychosocial outcomes of 54 overweight and obese adolescents. Participants were recruited and randomly assigned to the groups; competitive *exergame*, cooperative *exergame*, or control group. All *exergame* participants were encouraged to play for 30 to 60 minutes per day, while participants in the control group continued their regular daily activities. In the results, the researchers found that cooperative *exergame* players lost significantly more weight (mean 1.65 kg) than the control group, which did not lose weight. Adolescents in the cooperative *exergame* group also significantly increased their self-efficacy compared to the control group [28].

In relation to the anthropometric data reported by Canabrava *et al.* [29], there is a difference between the control and intervention groups, however this difference is not expressive when compared to the psychological effects that active games can provide, as in the study carried out by Andrade *et al.* [17].

Other authors such as Graves, Ridgers, Atkinson, & Stratton [30] and Madsen, Yen, Wlasiuk, Newman, & Lustig [31] also did not observe differences in the level of physical activity between the control and intervention groups. There were no reductions in BMI or percentage of body fat between the groups, corroborating the data of the present study.

Regarding the changes in eating habits and physical activity levels, it is possible the duration of the program, 12 weeks, was not enough to facilitate changes and that a longer program would cause observation of more changes in this framework.

Based on the data of the present study it was possible to verify that the exercise program with *exergames* allowed the children to get to know themselves and familiarize themselves with their bodies through virtual reality and thus, seek an elevation in their self-esteem which could reflect in a healthier adult life with better emotional conditions to face challenges.

Finally, *exergames* appear to be a very interesting tool to introduce the practice of physical activity into the daily life of obese or overweight and inactive children.

Conclusions

It was concluded that the use of *exergames* promoted a significant improvement in positive affect and a decrease in negative affects related to children's self-esteem and body image.

In the same way, a significant decrease was also observed in the values of the triceps and subscapular skinfolds in the Exergames group. On the other hand, it was not possible to identify significant differences in the variable physical activity level, eating habits, or BMI, supporting the hypothesis that there is a need for a longer intervention time in order to obtain more significant data on these variables.

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