PHYSIOLOGICAL AND PSYCHOAFFECTIVE RESPONSES OF ADULTS TRAINED IN ACUTE HIIT PROTOCOLS

RESPOSTAS FISIOLÓGICAS E PSICOAFETIVAS DE ADULTOS TREINADOS EM PROTOCOLOS AGUDOS DE HIIT

RESPUESTAS FISIOLÓGICAS Y PSICOAFECTIVAS DE ADULTOS ENTRENADOS EN PROTOCOLOS AGUDOS DE HIIT

Original Article
Artigo Original
Artículo Original

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ABSTRACT

High Intensity Interval Training (HIIT) promotes similar adaptations and in some cases, superior to continuous aerobic training of moderate intensity, even when performed at all-out intensities. In this condition, it tends to have the greatest physiological disturbance and accumulation of metabolites compared to submaximal intensities, being one of the main factors associated with the negative response of pleasure in training. Objective: To verify the relationship between physiological and psychophysiological responses in order to repeat the training of two HIIT protocols of mesm volume load and different periods of work in trained adults of both sexes. Methods: In a randomized experiment, the sample consisted of 9 individuals aged 28±5 years, body mass 69.6±14.2 kg, height 169±0.1cm, BMI 24.1±2.3 kg/m2 and body fat percentage 20.2±7.9% practitioners of structured aerobic physical exercises for at least six months. Two different HIIT protocols were performed on an exercise bike, being (I) protocol 1:0.5, with prescribed intensity (80-90% of MAX HR), (II) protocol 1:2 with prescribed intensity (all-out) with total duration of effort of 20 minutes and interval of at least 48 hours between each session. Heart rate (HR), systemic blood pressure (SBP), subjective perception of exertion (SPE), visual analog scale (VAS), affective response (AR), fun (PACES) and intention to repeat the session were analyzed. The statistical analysis used was ANOVA with Tukey's post-hoc ($p<0.05$). Results: The analyses of HR, SBP, VAS, PACES and SPE showed no significant difference between the training protocols. The affective response (AR and intention to repeat) showed a decline in the protocol 1:0.5, but without significance ($p>0.05$). Conclusion: The data allow us to conclude that the 1:2 protocol caused greater physiological disturbances during exertion and presented greater positive affective response and intention to repeat the exercise session, variables that may contribute to adherence to regular physical exercise. ***Level of Evidence I; Therapeutic studies - Investigation of treatment results.***

Keywords: HIIT short; Acute training; Affection; Adherence.

RESUMO

O Treinamento Intervalado de Alta Intensidade (HIIT) promove adaptações semelhantes e em alguns casos, superiores ao treinamento aeróbico contínuo de intensidade moderada, mesmo quando executado em intensidades all out. Nesta condição, tende a maior perturbação fisiológica e acúmulo de metabólitos comparado a intensidades submáximas, sendo um dos principais fatores associados a resposta negativa de prazer no treinamento. Objetivo: Verificar qual relação entre respostas fisiológicas e psicofisiológicas na intenção de repetir o treinamento de dois protocolos HIIT de mesmo volume load e distintos períodos de trabalho, em adultos treinados de ambos os sexos. Métodos: Em experimento randomizado, a amostra foi composta por 9 indivíduos com idade entre 28±5 anos, massa corporal 69,6±14,2 kg, estatura 169±0,1cm, IMC 24,1±2,3 kg/m^2 e percentual de gordura corporal 20,2±7,9% praticantes de exercícios físicos aeróbicos estruturados por pelo menos seis meses. Realizaram dois diferentes protocolos de HIIT em bicicleta ergométrica, sendo (I) protocolo 1:0,5, com intensidade prescrita (80-90% da $FC_{máx}$), (II) protocolo 1:2 com intensidade prescrita (all-out) com duração total de esforço de 20 minutos e intervalo de pelo menos 48 horas entre cada sessão. Foram analisados frequência cardíaca (FC), pressão arterial sistêmica (PAS), percepção subjetiva de esforço (PSE), escala visual analógica (EVA), resposta afetiva (FS), divertimento (PACES) e intenção de repetir a sessão. A análise estatística usada foi ANOVA com post-hoc de Tukey ($p<0,05$). Resultados: As análises da FC, PAS, EVA, PACES e PSE não apresentaram diferença significativa entre os protocolos de treinamento. As respostas afetivas (FS e intenção de repetir) apresentaram maior declínio no protocolo 1:0,5, porém sem significância ($p>0,05$). Conclusão: Os dados permitem concluir que o protocolo 1:2 provocou maiores perturbações fisiológicas durante esforço e apresentou maior resposta afetiva positiva e intenção de repetir a sessão de exercício, variáveis que podem vir a contribuir na aderência à prática regular de exercícios físicos. ***Nível de Evidência I; Estudos terapêuticos – Investigação dos resultados do tratamento.***

Descritores: *HIIT curto; Treinamento agudo; Afetividade; Aderência.*

RESUMEN

El entrenamiento de intervalos de alta intensidad (HIIT) promueve adaptaciones similares y, en algunos casos, superiores al entrenamiento aeróbico continuo de intensidad moderada. En esta condición, tiende a tener una mayor alteración fisiológica y acumulación de metabolitos en comparación con las intensidades submáximas, siendo uno

Associate Editor responsible for the review process: Paulo Zogaib

de los principales factores asociados con la respuesta negativa del placer en el entrenamiento. Objetivo: Verificar la relación entre las respuestas fisiológicas y psicofisiológicas para repetir el entrenamiento de dos protocolos HIIT de carga del mismo volumen y diferentes períodos de trabajo en adultos entrenados de ambos sexos. Métodos: En un experimento aleatorizado, la muestra estuvo constituida por 9 individuos de 28±5 años, masa corporal 69,6±14,2 kg, altura 169±0,1cm, IMC 24,1±2,3 kg/m2 y porcentaje de grasa corporal 20,2±7,9% practicantes de ejercicios físicos aeróbicos estructurados durante al menos seis meses. Se realizaron dos protocolos HIIT diferentes en bicicleta estática, siendo protocolo 1: 0,5, con intensidad prescrita (80-90% de la FC MÁXIMA), protocolo 1: 2 con intensidad prescrita (total) con duración total del esfuerzo de 20 minutos e intervalo de al menos 48 horas entre cada sesión. Se analizaron la frecuencia cardíaca (FC), presión arterial sistémica (PAS), percepción subjetiva de esfuerzo (PSE), escala analógica visual (EVA), respuesta afectiva (FS), diversión (PACES) e intención de repetir la sesión. El análisis estadístico utilizado fue ANOVA con post-hoc de Tukey (p<0,05). Resultados: Los análisis de HR, PAS, EVA, PACES y PSE no mostraron diferencias significativas entre los protocolos de entrenamiento. La respuesta afectiva (FS e intención de repetir) mostró una disminución en el protocolo 1:0,5, pero sin significancia (p>0,05). Conclusión: Los datos permiten concluir que el protocolo 1:2 causó mayores alteraciones fisiológicas durante el esfuerzo y presentó mayor respuesta afectiva positiva e intención de repetir la sesión de ejercicio, variables que pueden contribuir para la adhesión al ejercicio físico.
Nivel de Evidencia I; Estudios Terapéuticos - Investigación de los Resultados del Tratamiento.

Descriptores: *HIIT corto; Entrenamiento agudo; Afecto; Adherencia.*

DOI: http://dx.doi.org/10.1590/1517-8692202430022023_0076i Article received on 02/08/2023 accepted on 08/08/2023

INTRODUCTION

High-intensity interval training (HIIT) has shown several cardiometabolic benefits in adults with or without chronic conditions, even when compared to continuous moderate-intensity training (CMIT).[1-3]

HIIT promotes greater expression of metabolites, GH, epinephrine and blood lactate concentration, often observed in *all-out* stimuli. On the other hand, maximum stimuli tend to alter the perception of efficacy and bring negative responses in the perception of pleasure,[4-6] with a strong association with adherence to exercise programs in the medium and long term.[7,8]

HIIT is characterized by repetitive, short-term efforts with an intensity of effort above 85-90% of peak oxygen consumption (VO_{2peak}) or 85-95% of heart rate (HR) or above 15 on Borg's subjective perception of exertion scale (SPE- 6-20) and interspersed with periods of passive recovery or light intensity.[9,4,10]

The manipulation of HIIT variables improves cardiometabolic and psycho-affective responses both acutely[11,4] and chronically, such as an increase in mitochondrial content and capillary density, as well as an increase in stroke volume and cardiac output.[12]

Batacan *et al.*[13] showed that short-term HIIT interventions (>12 weeks) improved VO_{2max}, diastolic blood pressure and fasting blood glucose, while long-term interventions (<12 weeks) showed improvements in body composition, VO_{2max}, systolic blood pressure and resting heart rate. In addition to these benefits previously found in the literature in long and/or short chronic interventions, HIIT has several other health benefits, including psychological ones when it comes to acute interventions. However, the effect of HIIT on psycho-affective responses remains inconclusive, considering the effect of manipulating the variables. A study of 26 sedentary adults who underwent six sessions of protocols, including HIIT, 4 to 6 × 30 seconds of maximum sprints on a cycle ergometer against a resistance of 7.5% of body mass, with 4 minutes of recovery between sprints. The continuous aerobic training protocol: aerobic cycling for 40 to 60 minutes. The results showed a negative affective response to HIIT compared to moderate-intensity continuous training, suggesting a greater reduction in pleasure from training in the HIIT protocol.[14] The same trend was found by Bartlett *et al.*[15] investigating perceived pleasure in active men in HIIT versus continuous protocols. Olney *et al.*[16] presented four interventions, three of which were variations of HIIT (SIT, HIIT-short and HIIT-long), pointing out that all HIIT interventions showed higher heart rate, blood pressure and perceived exertion compared to continuous aerobics, but the psycho-affective responses of the HIIT models showed greater displeasure throughout the session.

No studies were identified that investigated the physiological and psycho-affective responses to two HIIT protocols with the same volume load and different recovery intervals. Thus, the aim of this study was to verify the relationship between physiological and psychophysiological responses to the intention to repeat HIIT training, with two HIIT protocols with similar volume *loads* and different recovery periods in trained adults of both sexes.

METHODOLOGICAL PROCEDURES

Sample

Men (n = 5) and women (n = 4) aged between 28±5 years, with a body mass of 69.6±14.2 kg, height of 169±0.1 cm, BMI of 24.1±2.3 kg/m^2 and body fat percentage of 20.2±7.9% took part in this study, whose characterization is shown in Table 1.

The inclusion criteria consisted of individuals practicing structured aerobic physical exercise for at least six months (experience in aerobic training for at least six months prior to the experiment, such as street running, hiking, cycling, mountain biking, or similar) of both sexes and aged between 20 and 40 years. The subjects filled in a health history questionnaire claiming no known cardiorespiratory or muscular

Table 1. Characterization of the sample.

Sample characterization	
Variable	**Mean±SD (n=9)**
Age (years)	28.3±5.5
Sex (female [%])	4 [44.4%]
Sex (male [%])	5 [55.6%]
Height (cm)	169±0.1
Body mass (kg)	69.6±14.2
Body mass index ($^{kg\text{-}m\text{-}2}$)	24.1±2.3
Fat mass (%)	20.2±7.9
Fat mass (kg)	16±9.4
Fat-free mass (kg)	39.9±9.9
Waist circumference (cm)	76.5±10
Hip circumference (cm)	100.7±6.3
RCQ (cm/cm)	0.76±0.07

(N = 19, mean ± SD).

contraindications or any use of medication that would modify the results of the study. All participants were instructed about the procedures and provided written informed consent before taking part in the study, whose procedures were approved by the Ethics Committee of Universidade São Judas Tadeu, SP, under opinion number 5.321.342.

The volunteers made three visits to a training studio separated by at least 48 hours before starting the interventions. Two groups of protocols: (G1) and (G2) were randomized. The first visit was aimed at explaining the study procedures, completing the pre-participation questionnaires (SF36), the informed consent form (ICF), anthropometric assessments (height, circumferences, mass and body composition) and prediction of maximum heart rate (HR_{max}) to stipulate work intensity. The second and third visits were aimed at carrying out the experimental protocols. The volunteers were instructed to refrain from any kind of physical activity during the collection period, as well as from consuming stimulating drinks such as energy drinks, caffeine compounds or similar, and to maintain their eating habits.

Training protocol

All the sessions were carried out on an exercise bike *(*Tp100 Oneal spinning bike) with a familiarization phase (five minutes) between 60% - 70% of the predicted HR_{max} and SPE between 13 - 15 on the Borg scale.[17] In protocol 1, 10 30-second sprints were carried out at an intensity equivalent to *all out (20 on the Borg* scale*),* with a 60-second passive recovery (protocol = 1:2). In protocol 2, 10 60-second sprints were performed at an intensity of 80-90% of HR_{max} (17-19 on the Borg chart)[17] with 30 seconds of passive recovery between them (protocol = 1:0.5). Both interventions had their volumes equalized over the total time (~20 minutes).

Physiological measurements

HR was measured using a chest strap (Polar H10) and SBP was measured by auscultation using a digital sphygmomanometer. In both interventions, HR and SBP were measured 10 minutes after the volunteers arrived at rest, before the start of the protocol, immediately at the start of the first stimulus and at the fifth sprint (equivalent to 50% of the protocol), at the end, as well as 15 and 30 minutes after the protocols. The mean values for both HR and SBP were defined according to the mean values obtained at times of exertion, without taking into account the moment of familiarization.

Psycho-affective measures

Before the surveys, the participants were instructed on the tables and scales and what they covered. They were instructed to answer the scales based on what they were feeling at the time. The assessment of perceived exertion (SPE) was recorded at the same time as the physiological tests. Affectivity (AR - 11-point scale, rated +5 (very good) to -5 (very bad) was collected on arrival, immediately at the start, 50 and 100% into the test and at 15 and 30 minutes after the experiment.[16] The visual analogue scale (VAS) was used on arrival, after familiarization, on the fifth day and immediately after the end of each training session, as well as at 15 and 30 minutes after the protocols.[18] The Intention to repeat the session and enjoyment (PACES), anchored at 7 points, 4 of which were "neutral", were collected after each session.

Statistical analysis

G-Power software was used to calculate the sampling power. The Shapiro-Wilk normality test for normal distribution identified symmetry. The one-factor ANOVA test was used to analyze HR and SBP, psychophysiological (VAS and SPE) and affective (AR and PACES) when comparing the moments. The paired T-test was used to compare the Intention to Repeat the Session. The effect size was revealed by calculating Cohen's *d*. Values of *d=0.2*, 0.5 and 0.8 indicate small, medium and large effect sizes, respectively. Statistical significance was set at $p<0.05$.

RESULTS

The average HR and SBP in the sessions were 150±34bpm; 153±30bpm, 145±19/ 85±8; 149±23/ 85±11, respectively. These figures show that the participants were trained.

Change in heart rate between protocols

Comparisons of HR between the protocols are shown in Table 2A.

The values from the 1:0.5 protocol were adopted as the baseline for comparison. ANOVA showed no significant difference ($p>0.05$) between the protocols at the moments of effort. There was an effect on HR over time in which a gradient in cardiac responses was observed. (Table 2B)

Change in systemic blood pressure between protocols

Comparisons of systolic and diastolic blood pressure between the two protocols are shown in Tables 3A and 3B, respectively. ANOVA showed no difference between protocols ($p=0.27$).

Change in affectivity, assessment of perceived exertion and enjoyment of physical activity between protocols

The positive effect diminishes during exercise. There was a 16% reduction between the two protocols. ANOVA revealed no difference between the protocols ($p>0.05$), indicating that the different stimuli did not alter the affective response. The affectivity data is shown in Table 4A.

There was a reduction in the affective response during exertion and after the protocols. (Table 4B)

Perceived exertion was superior in the 1:2 protocol and inversely related to the affective response, with linear growth (Figure 1). ANOVA showed no significant difference between the protocols ($p>0.05$), as well as in the responses of pleasure and enjoyment in physical activity.

Table 2A. Analysis of heart rate during exertion between different HIIT protocols in trained adults of both sexes.

Heart rate on exertion									
Protocol	N	Average	SD	% HR_{max}	95% CI	Delta %	Effect size	D Cohen	p-value
1:0.5	27	150	34	80%	(137.79; 162.51)	-2%	-0.031	-0.062	0.764
1:2	27	153	30	82%	(140.42; 165.14)				

Table 2B. Analysis of the segmented mean heart rate between different HIIT protocols in trained adults of both sexes.

Heart rate - segmented average							
Protocol	N	Average rest	Average 1st half	Average 2nd half	Overall average	Average 15' after	Average 30' after
1:0.5	54	71	139	172	156	98	91
1:2	54	70	143	172	158	97	87

Table 3A. Analysis of Systolic Blood Pressure during exertion between different HIIT protocols in trained adults of both sexes.

Systolic blood pressure - on exertion								
Protocol	N	Average	SD	95% CI	Delta %	Effect size	D cohen	p-value
1:0.5	27	145	19	(137.34; 153.32)	5%	0.14	0.28	0.271
1:2	27	139	23	(131.08; 147.06)				

Table 3B. Analysis of Diastolic Blood Pressure during exertion between different HIIT protocols in trained adults of both sexes.

Diastolic blood pressure - on exertion								
Protocol	N	Average	SD	95% CI	Delta %	Effect size	D cohen	p-value
1:0.5	27	85	8	(81.02; 88.46)	-1%	-0.036	-0.072	0.79
1:2	27	85	11	(81.72; 89.17)				

Table 4A. Affective response analysis *Feeling Scale* between different HIIT protocols in trained adults of both sexes.

Feeling scale - effort								
Protocol	N	Average	SD	95% CI	Delta %	Effect size	D cohen	p-value
1:0.5	27	1	3	(0.385; 2.430)	-16%	-0.18	-0.37	0.72
1:2	27	2	3	(0.644; 2.689)				

Table 4B. Analysis of the segmented average of the *Feeling Scale* between the different HIIT protocols in trained adults of both sexes.

Feeling scale - segmented average							
Protocol	N	Average start	Average 1st half	Average 2nd half	Overall average	Average 15' after	Average 30' after
1:0.5	54	5	2	0	3	3	4
1:2	54	5	2	0	3	4	4

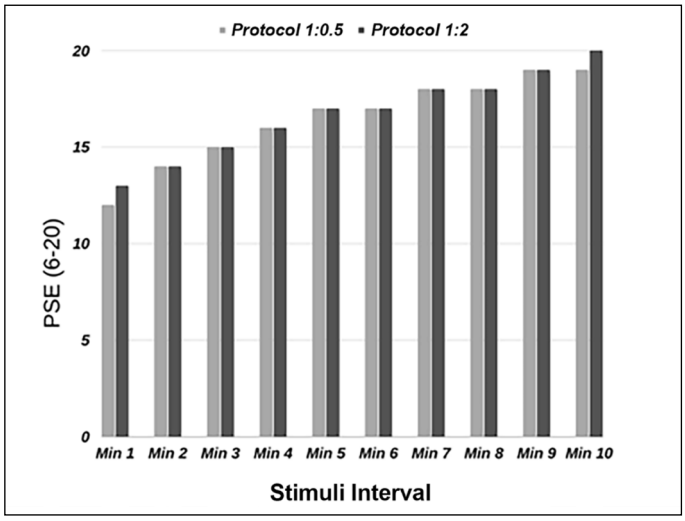

Figure 1. Analysis of the behavior of Subjective Perception of Effort segmented by effort stimuli between different HIIT protocols in trained adults of both sexes.

Changes in the intention to repeat the session

The greatestintention to repeat the session was in the 1:2 protocol, with no statistical difference (p>0.05). The 30:60 *(all out)* protocol showed greater pre-involvement intention before the protocol, which decreased after the procedure. (Table 5A)

The intention to repeat the training session showed no significant difference between the different assessment times for intention, indicating that the different protocols did not alter the participants' responses. (Table 5B)

DISCUSSION

This study compared the physiological responses to two different HIIT protocols: (I) 1:0.5 protocol and (II) 1:2 protocol. Our study highlights the importance of investigating the relationship between physiological, psychophysiological and psycho-affective valences, as well as the physiological implications for the others.

The physiological responses between two HIIT protocols with the same volume *load* and different effort intervals showed no statistical differences in HR and SBP. HR was not different in the protocols (p=0.764). The greatest physiological disturbance occurred in the second half of the experiment (172 bpm) in both protocols when compared to the first half (139 bpm; 143 bpm) for the 1:0.5 and 1:2 protocols, respectively. These findings suggest that physiological responses are more altered as a result of the time spent on exertion. The behavior of the HR is associated with the inability to increase abruptly in the initial sprints due to the short period of time under effort, since the HR was maintained under increase

Table 5A. Analysis of the intention to repeat the session, pre and post, for a 1:2 ratio HIIT protocol in trained adults of both sexes.

Intention to repeat the session Protocol 1:2							
Protocol 1:2	n	Average	SD	Delta %	Effect size	D cohen	p-value
Intention 1 - before	9	5	2	21%	0.175	0.36	0.228
Intention 1 - after	9	4	2				
Intention 2 - before	9	5	2	23%	0.204	0.417	0.212
Intention 2 - after	9	4	2				

Table 5B. Analysis of the intention to repeat the session, pre and post, for a 1:0.5 ratio HIIT protocol in trained adults of both sexes.

Intention to repeat the session Protocol 1:0.5							
Protocol 1:0.5	N	Average	SD	Delta %	Effect size	D cohen	p-value
Intention 1 - before	9	4	2	12%	0.103	0.208	0.225
Intention 1 - after	9	4	2				
Intention 2 - before	9	4	2	12%	0.106	0.213	0.225
Intention 2 - after	9	4	2				

even in the recovery interval.[10] The high maintenance of the HR occurs due to the participation of the large muscle volume of the lower limbs contributing to the production of metabolites and greater removal of metabolites, corroborating Gosselin et al.[19] who investigated the metabolic responses of different HIIT protocols of 30:30, 60:60, 60:30 and 90:30 seconds and found no significant difference in the physiological responses of HR between the 60:30 and 90:30 protocols. In a similar study, Myrkos et al. (2020),[20] investigated HIIT protocols, (120s:120s; 120:60; 60:60; 60:30) in HR responses, identifying a greater change in HR in the 120:120 protocol, which even in efforts to exhaustion, the duration of the effort-recovery, does not affect the exercise time.

Our findings show that both 1:2 and 1:0.5 HIIT provoke similar changes in physiological and perceptual responses to exertion. Studies show that longer effort intervals result in greater effort compared to shorter intervals, suggesting the effect of disturbing the acid-base balance,[21,22] which does not seem to have influenced the psycho-affective responses that were similar in the protocols (1:2: SPE=17; 1:0.5: SPE=16).

The results of this study considered three aspects when assessing psycho-affective responses: (I) affectivity through the pleasure scale (AR); (II) enjoyment in physical activity (PACES); (III) precursor mechanism to adherence through the intention to repeat the session, as proposed by Marin (2019).[23]

The greatest positive affective response occurred in the 1:2 protocol (30s:60s), although this was not shown to be significant by the statistics. We believe that the longer recovery interval would favor greater positive affective responses due to the recovery of baseline physiological parameters, leading to a reduction in the perception of pain and effort.

Corroborating our findings, Townsend et al.[24] investigated whether the manipulation of sprint and recovery durations, with a ratio of 1:8 in the SIT. The greatest positive affective response was in the SIT protocols 5s:40s and 15s:120s compared to 30s:240s.

Although it did not show a significant difference, both protocols showed a reduction in affect between sessions and tended to be less positive in the protocol with a longer recovery interval, even though greater effort and intensity were used (30:60 all out), corroborating Ekkekakis et al.[25], Oliveira et al.[26], Marin, 2019.[23]

The perception of pleasure is one of the main factors related to the practice and adherence to physical activity, considering the behavioral implications in the enjoyment and intention to maintain the practice of physical exercise.[27] With these discussions in mind, the use of instruments

related to pleasure and intention can contribute to adherence in exercise programs, since affective experiences during exercise, such as being pleasant to practice, can explain the intention to repeat the activity.[28,29]

CONCLUSION

The data show that the 1:2 protocol caused greater physiological disturbances during exertion, and a greater positive affective response and intention to repeat the exercise session. This study points to the importance of monitoring affective and physiological measures when prescribing HIIT training for adults. Future, longer-term studies could help predict adherence and motivation in HIIT programs.

All authors declare no potential conflict of interest related to this article

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of the manuscript. AV, AFJ were the main contributors to the writing of the manuscript. AV carried out the field collections, accompanied the volunteers and collected clinical data. AV, CS, WS and AFJ evaluated the data from the statistical analysis. AV, AFJ, WS, EB and CS carried out the bibliographical research, revised the manuscript and contributed to the intellectual concept of the study.

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