



ORIGINAL ARTICLE

# The effect of an initiation to struggles structured program on the physical capacities, visual attention and school performance in elementary school children

Harrison Vinícius Amaral da Silva <sup>a,\*</sup>, Tércio Amancio do Nascimento <sup>b</sup>,  
Tatiane Melo de Lima <sup>a</sup>, André dos Santos Costa <sup>a</sup>



<sup>a</sup> Universidade Federal de Pernambuco (UFPE), Programa de Pós-Graduação em Biodinâmica do Movimento Humano, Recife, PE, Brazil

<sup>b</sup> Universidade Federal de Pernambuco (UFPE), Departamento de Educação Física, Recife, PE, Brazil

Received 15 October 2017; accepted 11 April 2018

Available online 7 July 2018

## KEYWORDS

Child;  
Cognition;  
Physical education;  
Child development

## Abstract

**Objective:** To verify the effect of an initiation to struggle program (ISP) in the psychobiological aspects in elementary school children.

**Methods:** A quasi-experimental study, with 52 children divided in two groups: Control (CG,  $n=26$ , they did not participate in the ISP) and Intervention (IG,  $n=26$ , they participate in the ISP). The ISP was based on opposition children's games with struggles' characteristic. The TAVIS-4 program (to evaluate visual attention), the TDE (Scholar Performance Test) and the PROESP-BR tests (to evaluate physical capacities) were utilized in this study.

**Results:** Significant differences were observed in the physical capacities, visual attention and scholar performance.

**Conclusion:** The ISP seems to be positive in aspects of child's development.

© 2018 Colégio Brasileiro de Ciências do Esporte. Published by Elsevier Editora Ltda. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## PALAVRAS-CHAVE

Crianças;  
Cognição;  
Educação física;  
Desenvolvimento infantil

**O efeito de um programa estruturado de iniciação as lutas sobre as capacidades físicas, a atenção visual e o desempenho escolar em crianças do ensino fundamental**

## Resumo

**Objetivo:** Verificar o efeito de um programa de iniciação as lutas (PIL) sob os aspectos psicobiológicos em crianças do ensino fundamental.

**Metodologia:** Estudo quase experimental, composto por 52 crianças divididas em dois grupos: controle (GC,  $n=26$ , não participantes do PIL) e intervenção (GI,  $n=26$ , participantes do PIL). O PIL foi baseado em jogos e brincadeiras de oposição com aspectos das lutas. Foram usados o programa TAVIS-4 (Avaliação da Atenção Visual), TDE (Teste de Desempenho Escolar) e a Proesp-BR (Avaliação das Capacidades Físicas).

\* Corresponding author.

E-mail: [harrison.silva@ufpe.br](mailto:harrison.silva@ufpe.br) (H.V. Silva).

**PALABRAS CLAVE**

Niño;  
Cognición;  
Educación física;  
Desarrollo infantil

*Resultados:* Foram observadas diferenças significativas nas capacidades físicas, atenção visual e desempenho escolar.

*Conclusão:* O PIL parece favorecer aspectos do desenvolvimento da criança.

© 2018 Colégio Brasileiro de Ciências do Esporte. Publicado por Elsevier Editora Ltda. Este é um artigo Open Access sob uma licença CC BY-NC-ND (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## El efecto de un programa estructurado de iniciación a la lucha en las capacidades físicas, la atención visual y el rendimiento escolar en niños de enseñanza primaria

### Resumen

*Objetivo:* Comprobar el efecto de un programa de iniciación a la lucha (PIL) en aspectos psicobiológicos en niños de enseñanza primaria.

*Métodos:* Un estudio cuasi-experimental, con 52 niños divididos en dos grupos: control (GC, n=26, que no participó en el PIL) y de intervención (GI, n=26, que participó en el PIL). El PIL se basó en juegos infantiles de oposición con aspectos de la lucha. Se utilizó el programa TAVIS-4 (Evaluación de la Atención Visual), el TDE (Prueba de Desempeño Escolar) y la batería PROESP-BR (Evaluación de las Capacidades Físicas).

*Resultados:* Se observaron diferencias importantes en las capacidades físicas, atención visual y desempeño escolar.

*Conclusión:* El PIL parece fomentar aspectos del desarrollo del niño.

© 2018 Colégio Brasileiro de Ciências do Esporte. Publicado por Elsevier Editora Ltda. Este es un artículo Open Access bajo la licencia CC BY-NC-ND (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## Introduction

Performing physical activity leads to very important changes in the person's organism, improving many aspects related to health such as decreasing the risk of future diseases, reducing obesity and neuroinflammation, ameliorating quality of life and may positively impact the cognition (Benatti and Pedersen, 2005; Miller and Spencer, 2014; Nahas, 2001; Westfall et al., 2017). It is notorious that the physical activity practice should start in childhood, since it is in this period of life that habits and values are acquired (Guedes, 1999). Hence, it is essential that scholar physical education occur with activities promoting health, autonomy, creative and critic development (Brasil, 1997; Gallahue and Donnelly, 2007).

The physical education national curriculum parameters (PENCP) indicate three fundamental blocks of contents to elementary school: 1 – Knowledge about the body; 2 – Sports, struggles and gymnastics and 3 – Rhythmic and expressive activities (Brasil, 1997). The struggle, as scholar content, may assume several arrangements, from children games such as "tug-of-war", "cockfight" to refined art martial techniques. However, it is suggested a playful approach to insert this topic at school, in a way students may be able to experience the corporal culture (Brasil, 1997). Despite that struggling elicit numerous benefits to individuals, nowadays this content utilization is insufficient discussed between physical education teachers, and the struggles studies within the physical education are incipient as well (Correia and Franchini, 2009).

Specifically about the struggles, some researchers demonstrate that the practice of struggles or martial arts have positive effects in diverse features (Rios et al., 2017).

In a physical aspect, decrease in stress, improvements in balance and strength could be highlighted; in a social aspect, reduction of aggressiveness, uplift in self-esteem and social interaction might be noticed (Reynes and Lorant, 2001). Regarding the brain, enhancing in cognition and arithmetic test performance can be verified (Lakes and Hoyt, 2004).

According to Olivier (2000), children games, in childhood, may improve motor and cognitive functions and it contributes to the motivation to study as well, as the children use many neuromotor stimuli during classes, and these activities promote enhancements in velocity, reflex and reaction time. In this sense, a study observed, through resonance magnetic imaging, that long-term judo practitioners develop higher gray matter volume in diverse areas of the brain when compared to a control group, showing that this kind of physical activity favors the subject's brain development (Jacini et al., 2009). Thus, the proposal of a struggle based content and the evaluation of its effects in children may generate an extremely important product to scholar physical education; moreover, it might help to guide the use of this content more effectively.

Therefore, the aim of this study is to verify the effect of an initiation to struggles structured program on the physical capacities, visual attention and school performance in elementary school children.

## Material and methods

### Study design

This is a quasi-experimental study, with sample chosen by convenience, composed by two groups: participants in an

initiation to struggle structured program (IG,  $n=26$ ) and non-participants in the program, which it is called control group (CG,  $n=26$ ). The groups were established in order to do not disturb the school daily routine. Thus, we randomly choose two groups from the elementary school (4th grade A and B); the choice was made by simple randomization. It is important to recognize that it was a municipal school from Recife, the children from both groups did not have scholar physical education since it is not mandatory by the city government.

The intervention consists of an initiation to struggle structured program with children games and opposition games. The evaluation occurred before and right after the end of the program to both groups, with the following data gathered: sociodemographic data; physical capacities; selective, alternated and sustained attention; and scholar performance.

## Participants

The sample has 52 children, both genders, age ranging from 8 to 12 years old, divided into control groups (CG) and intervention (IG). The study was developed in a school in the city of Recife/PE, Brazil. Some aspects should be enlighten such as the absence of scholar physical education classes as a curricular component in the referred school; all the children were in the fourth grade in elementary school and the children in each group (CG and IG) were in different classes and were taught by different teachers.

The study was approved by the Ethical Research Committee involving Human Beings of Federal University of Pernambuco, n. 1.379.114. The parents and/or responsible for the children were informed about the research and they signed the Consent Term. The children must be in the elementary school to participate in the study; they could not have any neuropsychology disease or deficiency that might disturb the performance in the evaluation and intervention.

## Sociodemographic data

The sociodemographic data collected were age, body mass, height, body mass index (BMI), sexual maturation and physical activity level. The body mass and the height were measured to calculate the BMI ( $BMI = \text{weight}/\text{height}^2$ ). The sexual maturation was evaluated as proposed by Tanner (1981). The physical activity level was evaluated through the Three-Day Reminder of Adapted Physical Activity (Damasceno, 2013). The videogame time was measured by a question asked directly to the participant.

## Physical capacities – aerobic fitness, agility and velocity

Aerobic fitness, agility and velocity were evaluated through the PROESP-BR tests. To assess the aerobic fitness, two points were marked on the floor, with a 6 m distance between them, where the participants should go forward and back as many times as they could in the maximum time of six minutes; the distance was recorded. To assess the agility, the child performed a run in a 4 m square, moving in

all diagonals, completing 20 m; the time spent was recorded. To assess velocity, a 20 m distance was marked and the child should move as fast as possible from one point to another; the time spent was recorded (Gaya et al., 2012).

## Selective, alternated and sustained attention

The cognitive capacity Attention was measured by the computerized program TAVIS-4 (Visual Attention Test), which contains three distinct tasks adequate to the child's age aiming to evaluate selective, alternated and sustained attention. The computer retains and classify the errors by omission (EO) and the errors for action (EA) and also the mean reaction time (MRT) (Mattos and Coutinho, 2010).

## Scholar performance

The Academic Achievement Test (AAT) was adopted to assess the scholar performance. This instrument consists of the Writing subtest (it evaluates the children's ability to write correctly), Arithmetic subtest (it consists in finding the oral problems solution and calculus of arithmetic operations) and Reading subtest (the children must read out loud isolated words from the context). Besides the total score, the subtests score contains a scale with inferior, average and superior rating (Stein, 1995).

## Procedures

The data collection was realized individually at the school library and the court every other day. Sociodemographic data and physical capacities assessments were made followed by visual attention (selective, alternated and sustained) and scholar performance evaluation.

After the assessments, the interventions with IG begun and lasted 12 weeks, with two sessions per week, 50 min each. The proposed activities were children games with opposition games, divided in four fundamental blocks referring to the initiation to struggle, as characterized in Fig. 1.

## Statistical analysis

The data were analyzed through descriptive statistics and inferential statistics; non-parametric tests were used after the verification of non-normality of the data. The Wilcoxon test was applied for the intragroup comparisons; the Mann-Whitney  $U$  test and the  $T$ -test were utilized to the intergroup analysis, with the SPSS 20.0 program. The level of significance was  $p < 0.05$ .

## Results

The data regarding sociodemographic characteristics did not present significant differences between the groups (Table 1), except the age: children in CG showed a higher average than IG.

Table 2 illustrates the comparison of averages referring to aerobic fitness, agility and velocity. Significant differences were observed in the agility ( $p=0.003$ ) and velocity

CHILDREN GAMES AND OPPOSITION GAMES	SESSIONS
BALANCE; VELOCITY AND AGILITY	6
DODGE; GRAB; OBJECTS AND TERRITORY CONQUERING	6
RETENTION; IMOBILIZATION; RESISTANCE AND STRENGTH	6
MIXED ACTIVITIES FROM ALL CONTENTS	6
TOTAL	24

**Figure 1** Initiation to struggle fundamental blocks.

**Table 1** Sociodemographic characteristics of study participants.

	Control <i>n</i> = 26	Intervention <i>n</i> = 26	Independent <i>T</i> test	
			<i>T</i> value	<i>p</i> value
<i>Age, years</i>	10.54 (0.21)	9.85 (0.19)	-2.405	0.02*
<i>BMI, kg/m<sup>2</sup></i>	18.59 (0.78)	18.78 (0.68)	0.183	0.85
Eutrophic, percentage	15 (57.7)	14 (53.8)	-	-
Overweight, percentage	10 (38.5)	9 (34.6)	-	-
Obese, percentage	1 (3.8)	3 (11.5)	-	-
<i>Gender, ♂/♀, percentage</i>	10 (38.5)/16 (61.5)	15 (57.7)/11 (42.3)	-	-
<i>Sexual maturation, percentage</i>				
Pre-puberty (Stage 1 and 2)	7 (26.9)/7 (26.9)	10 (38.5)/7 (26.9)	-	-
Puberty (Stages 3)	12 (46.2)	4 (15.4)/3 (11.5)	-	-
Post-puberty (Stage 4 and 5)	-	1(3.8)	-	-
<i>Videogame, min</i>	104.42 (18.83)	111.92 (15.34)	0.309	0.75
<i>3DPA, min</i>	70.0 (8.41)	66.92 (11.68)	-0.214	0.83
Sedentary, percentage	12 (46.2)	13 (50)	-	-
Physically active, percentage	14 (53.8)	13 (50)	-	-

\* Statistic significant difference between groups ( $p < 0.05$ ). Results expressed in AVERAGE (SE).

**Table 2** Physical capacities assessment.

	Control ( <i>n</i> = 26)		Intervention ( <i>n</i> = 26)	
	Pre	Post	Pre	Post
Aerobic fitness (m)	572.31 (13.74)	552.04 (17.03)	587.58 (16.14)	571.54 (14.44)
Agility (s)	7.45 (0.117)	7.27 (0.111)	7.69 (0.178)	7.15 (0.133)*
Velocity (20 m test; seconds)	4.01 (0.076)	4.17 (0.070)	4.38 (0.097)	4.12 (0.085)*

\* Significant difference to time effect – *Pre* vs. *Post* (Willcoxon Test),  $p < 0.05$ . Results expressed in AVERAGE (SE).

( $p = 0.031$ ) to IG, with lower execution time registered after the intervention period.

Table 3 shows the Visual Attention and Scholar Performance evaluation. Significant differences were observed regarding errors for action (EA) in selective attention task ( $p = 0.000$ ) and alternated attention task ( $p = 0.001$ ) to IG, presenting a decrease in errors. It was observed in the CG a significant raise in the mean Reaction Time (MRT) in the Sustained Attention task ( $p = 0.013$ ) when compared to baseline. In scholar performance, it was observed a significant difference in the Reading Score ( $p = 0.008$ ) to IG (higher than

baseline) and in the General Score ( $p = 0.002$ ) to CG (higher than baseline).

## Discussion

The present study aimed to evaluate the effects of an initiation to struggles structured program in a scholar environment on the physical capacities, attention and school performance. After the 24 intervention sessions, our results demonstrate significant improvements in the agility and

**Table 3** Visual attention and scholar performance assessment.

	Control (n=26)		Intervention (n=26)	
	Pre	Post	Pre	Post
<b>Visual attention</b>				
<i>Selective attention</i>				
MRT(T/S)	0.55 (0.01)	0.52 (0.02)	0.56 (0.01)	0.56 (0.01)
EO(N.E)	3.31 (1.01)	4.38 (1.14)	2.65 (0.73)	2.12 (0.59)
EA(N.E)	7.15 (1.19)	6.42 (1.24)	8.81 (1.24)	4.69 (0.77)*
<i>Alternated attention</i>				
MRT(T/S)	0.63 (0.03)	0.66 (0.01)	0.63 (0.03)	0.59 (0.03)
EO(N.E)	2.24 (0.42)	2.62 (0.49)	2.24 (0.56)	1.64 (0.34)
EA(N.E)	6.12 (1.40)	3.81 (0.51)	6.48 (1.10)	2.48 (0.50)*
<i>Sustained attention</i>				
MRT(T/S)	0.59 (0.02)	0.66 (0.03)*	0.58 (0.01)	0.62 (0.02)
EO(N.E)	0.12 (0.08)	0.04 (0.03)	0.15 (0.12)	0.31 (0.14)
EA(N.E)	2.88 (1.20)	2.92 (0.60)	1.96 (0.40)	1.62 (0.28)
<b>Scholar performance</b>				
Writing (N.H)	16.65 (1.78)	17.85 (1.08)	13.12 (1.32)	13.27 (1.28)
Arithmetic (N.H)	14.15 (1.05)	15.19 (0.83)	11.73 (0.67)	12.85 (0.65)
Reading (N.H)	58.5 (1.99)	59.23 (2.65)	56.19 (2.61)	60.38 (1.47)*
General score (N.H)	89.31 (4.06)	92.27 (4.46)*	81.04 (3.89)	86.46 (2.86)

\* Significant difference to time effect – Pre vs. Post (Willcoxon Test),  $p < 0.05$ .

Results expressed in AVERAGE (SE).

EA, errors for action; EO, errors by omission; MRT, mean reaction time; N.E, number of errors; N.H, number of hits; T/S, tenth of a second.

velocity physical capacities in IG. Regarding to the cognitive capacity attention, the results express a reduction in the errors per action in the selective and alternating attention tasks in the children from IG. The CG presented an increase in the reaction average time in the sustained attention task. Regarding to the scholar development, it was observed an enhancement in the reading subtest to the IG, however, the CG presented an increase in the total score.

Regarding the effect of the intervention on the physical capacities, our results demonstrated that 24 sessions ameliorate only agility and velocity comparing IG to the CG. This result may be explained by the activity type experienced in the interventions, with six sessions focused on velocity and agility fundamentals. This results are in concordance with literature data, which point that struggle activities have, mainly, an intermittent characteristic, generating adaptations in the anaerobic system (Alm and Yu, 2013; Bouhler et al., 2006), therefore, influencing the physical capacities agility and velocity.

The possible effects of the intervention program in the cognition were explored as well. The hypothesis was that the improvement in the cognitive performance would occur due to the movement complexity of the struggle, promoting more stimuli to the Central Nervous System.

As Jacini et al. (2009) presented, it is hypothesized that the association between the practice of physical exercise involving complex motor planning causes changes in important brain areas. The authors investigated the gray matter volume in long-term judo practitioners (8 individuals) comparing to a control group (18 individuals). The results showed that the judo practitioners had higher gray matter

volume in the frontal, parietal, occipital and temporal lobes when compared to the control group. Another study, following the same idea, examined the acute effect of coordinative exercises in teenagers' attention performance. It was found that only 10 minutes of coordinative exercise promoted beneficial effects in the attention performance of the teenagers (Budde et al., 2008).

Lakes and Hoyt (2004), explored the Taekwondo training effect in some self-regulation abilities of 207 kindergarten and elementary school students, randomly divided by classroom in two groups: intervention group (Martial Arts) and control group (traditional physical education). The intervention occurred with general Taekwondo techniques, twice or three times a week during 3 months of scholar year. The results pointed that the intervention group presented improvements in the cognitive and affective self-regulation areas, in the pro-social behavior in classroom and in mathematic tests performance as well. In conclusion, they found that martial art training beneficially contributes to the self-regulation development in scholar children.

Regarding the cognitive capacity attention, our results indicate a decreasing in errors for action in the task of selective and alternated attention by the children who participated in the initiation to struggle program. This improvement in selective and alternated attention may occur due to the activity type performed, since the opposition games let the children focused in the task, which contributes to the visual attention s feedback.

The literature indicates that children games may influence cognition in childhood, as seen in the study of Rolim

et al. (2008), affirming that playful activities are essential to the construction of new learning, in the social cognitive aspect. In addition, several studies show these activities elicit positive effects in the central nervous system, since it is a physical activity (Lubans et al., 2016).

Some physiologic hypothesis gives support to the positive outcomes found in our study about the effect of physical activity and physical fitness to the brain's health such as: (1) increase in brain blood flow (Chaddock-Heyman et al., 2016); (2) increase in cortical electrical activity (Tomprowski et al., 2015); (3) neurogenesis (Van Praag, 2009).

The initiation to struggle program does not seem efficient to improve the children's scholar performance. The significant differences were found only in the reading subtest when comparing intervention and control groups, while the total score of the school performance was significantly improved in the control group. Indeed, the literature shows some gaps about the effect of physical activity in the scholar performance (Donnelly et al., 2016; Donnelly et al., 2017).

In a systematic review, Donnelly et al. (2016) investigated if the scholar physical education and sports programs could influence the scholar performance in children from 5 to 13 years old. The results observed were inconclusive, so it is not possible to affirm for sure that physical activity may influence the scholar performance, which points to the importance of realize studies with a better experimental design and methodological rigor (Donnelly et al., 2016).

The Donnelly et al. (2017) randomized clinical trial investigated during three years the effect of classroom physical activity in the academic performance. Despite the high methodological rigor of the study, it was not found significant difference between the groups that performed physical activity and the control group concerning the scholar performance. Some hypothesis were pointed by the authors to explain the results: (1) intensity – even with the students reaching the established goal, it was not enough to generate improvements in the scholar performance; (2) frequency – only in four days of the week the activities were offered, due to special events realized in the school environment; (3) teachers – some of them were reluctant and found difficulties doing the intervention in the classroom. Moreover, the authors highlight that the lack of specific information, even with previous training, may influence the intervention experience.

Some limitations of the study might be indicated as a possible reason to the lack of significance and interference related to the scholar performance such as: (1) despite of the children belong to equal groups (4th grade A and B), the CG presented a higher age range average when compared to the IG; (2) even though the children were in the same classes, they had different teachers, so the docent activity might have interfered in the children's scholar performance of the children; (3) The subjects were not familiarized with the applied tests, with a familiarity we could have a greater reproduction of the tests; (4) As a result, it is perceptible the complexity and diversity of factors that may interfere in the children's scholar performance. It is important to highlight, regardless of the presented limitations, this study seems to be pioneer in the investigation of psychobiological variables inside the school, preserving the ecological validity.

## Conclusion

The children who participated in the initiation to struggle program seems to present positive responses to the agility and velocity physical capacities and in some aspects of visual attention as well. Nevertheless, more studies are necessary, due to the presented limitations, to elucidate some hypothesis raised in this research.

## Financial support

The present work had financial support in the nature of scholarship, granted through the Fund of Support to Science and Technology of Pernambuco.

## Conflicts of interest

The authors declare no conflicts of interest.

## Acknowledgments

To the Study Group on Physical Exercise, Nutrition and Central Nervous System, the Foundation of Support to Science and Technology of Pernambuco, for the support and encourage to the research, and to the municipal school directors for the support to the research realization.

## References

- Alm P, Yu J. *Physiological characters in mixed martial arts*. *Am J Sports Sci* 2013;1:12–7.
- Benatti FB, Pedersen BK. *Exercise as an anti-inflammatory therapy for rheumatic diseases – myokine regulation*. *Nat Rev Rheumatol* 2005;11:86–97.
- Bouhleb E, Jouini A, Gmada N, Nefzi A, Ben AK, Tabka Z. *Heart rate and blood lactate responses during Taekwondo training and competition*. *Sci Sports* 2006;21:285–90.
- Brasil. *Parâmetros Curriculares Nacionais: Educação Física*. Brasília: Secretaria de Educação Fundamental, MEC/SEF; 1997.
- Budde H, Voelcker-Rehage C, Pietrafyk-Kendziorra S, Ribeiro P, Tidow G. *Acute coordinative exercise improves attentional performance in adolescents*. *Neurosci Lett* 2008;441:219–23.
- Chaddock-Heyman L, Erickson KI, Chappell MA, Johnson CL, Kienzler C, Knecht A, et al. *Aerobic fitness is associated with greater hippocampal cerebral blood flow in children*. *Dev Cogn Neurosci* 2016;20:52–8.
- Correia WR, Franchini E. *Produção acadêmica em lutas, artes marciais e esportes de combate, Motriz*. *Revista de Educação Física* 2009;16:1–9.
- Damasceno VO. *Adaptação Transcultural e Qualidades Psicométricas do Diário Three Day Physical Activity Recall em Escolares de 10 a 12 ANOS [Tese de Doutorado]*. Departamento de Pediatria. Faculdade de Medicina. Universidade Federal de Minas Gerais; 2013.
- Donnelly JE, Hillman CH, Castelli D, Etnier JL, Lee S, Tomporowski P. *Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review*. *Med Sci Sports Exerc* 2016;48:1197–2122.
- Donnelly JE, Hillman CH, Greene JL, Hansen DM, Gibson CA, Sullivan DK, et al. *Physical activity and academic achievement across the curriculum: results from a 3-year cluster-randomized trial*. *Prev Med* 2017;99:140–5.

- Gallahue DL, Donnelly FC. *Developmental physical education for all children*. Hum Kinet 2007.
- Gaya A, Lemos A, Gaya A, Teixeira D, Pinheiro E, Moreira R. *Projeto Esporte Brasil (Proesp-Br)*. Manual de Testes e Avaliação; 2012.
- Guedes DP. Educação para a saúde mediante programas de educação física escolar. *Motriz* 1999;5:10-4.
- Jacini WFS, Cannonieri GC, Fernandes PT, Bonilha L, Cendes F, Li LM. Can exercise shape your brain? Can exercise shape your brain? Cortical difference associated with judô practice. *J Sci Med Sport* 2009;12:688-90.
- Lakes KD, Hoyt WT. Promoting self-regulation through school-based martial arts training. *J Appl Dev Psychol* 2004;25:283-302.
- Lubans D, Richards J, Hillman C, Faulkner G, Beauchamp M, Nilsson M, et al. Physical activity for cognitive and mental health in youth: a systematic review of mechanisms. *Pediatrics* 2016;138:2-13.
- Mattos P, Coutinho G. Teste de atenção visual (Tavis-3). *Avaliação neuropsicológica*. Porto Alegre: Artmed; 2010. p. 332-6.
- Miller AA, Spencer SJ. Obesity and neuroinflammation: a pathway to cognitive impairment. *Brain Behav Immun* 2014;42:10-21.
- Nahas MV. *Atividade física saúde e qualidade de vida: conceitos e sugestões para um estilo de vida ativo*. Midiograf 2001.
- Olivier J-C. *Das brigas aos jogos com regras: enfrentando a indisciplina na escola*; 2000.
- Reynes E, Lorant J. Do competitive martial arts attract aggressive children? *Percept Motor Skills* 2001;93:382-6.
- Rios SO, Marks J, Estevan I, Barnett L. Health benefits of participation in selected 'hard' martial arts for adults: a systematic review. *J Sci Med Sport* 2017;20:43.
- Rolim AAM, Guerra SSF, Tassigny MM. Uma leitura de Vygotsky sobre o brincar na aprendizagem e no desenvolvimento infantil. *Revista Humanidades* 2008;23:176-80.
- Stein LM. *TDE: teste de desempenho escolar: manual para aplicação e interpretação*. São Paulo: Casa do Psicólogo; 1995. p. 1-17.
- Tanner JM. Growth and maturation during adolescence. *Nutr Rev* 1981;39:43-55.
- Tompsonski PD, McCullick B, Pendleton DM, Pesce C. Exercise and children's cognition: the role of exercise characteristics and a place for metacognition. *J Sport Health Sci* 2015;4:47-55.
- Van Praag H. Exercise and the brain: something to chew on. *Trends Neurosci* 2009;32:283-90.
- Westfall DR, Kao S-C, Scudder MR, Pontifex MB, Hillman CH. The association between aerobic fitness and congruency sequence effects in preadolescent children. *Brain Cogn* 2017;113:85-92.