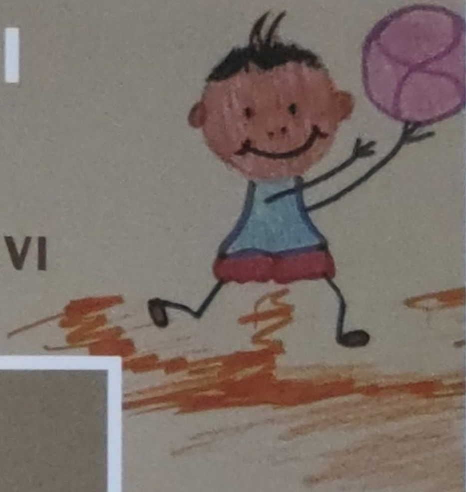
ESTUDOS EM DESENVOLVIMENTO MOTOR DA CRIANÇA XVI



MOTOR DEVELOPMENT STUDIES OF THE CHILD XVI

Eds.

Maria João Lagoa
Diogo Coutinho
Carlos Carvalho
José Oliveira Santos
João Viana
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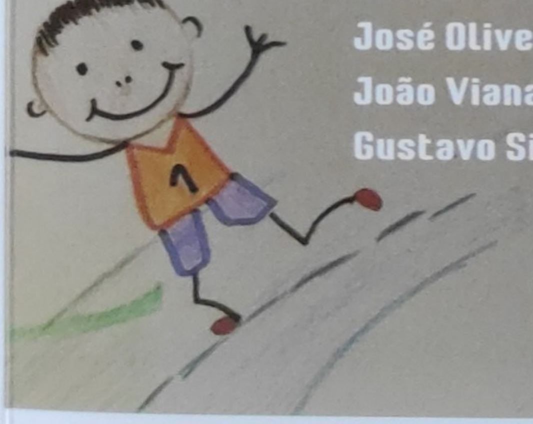

EDIÇÕES ISMAI

O XVIII Seminário do Desenvolvimento Motor em Crianças (XVIII SDMC) procura, assim, abordar questões práticas e refletir sobre aspetos conceptuais para que os especialistas deste ramo do saber estejam bem preparados para enfrentar os problemas da aprendizagem, do desenvolvimento e do controle motor.

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LEARNING TO CYCLE: WHY IS THE BALANCE BIKE MORE EFFICIENT THAN THE BICYCLE WITH TRAINING WHEELS?

APRENDER A CICLAR: PORQUE É QUE A BICICLETA DE EQUILÍBRIO É MAIS EFICIENTE DO QUE BICICLETA COM RODAS DE TREINO?

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Abstract

Recent research indicates that the balance bike (BB) is most efficient to learn to cycle than the bicycle with lateral training wheels (BTW), but reasons for this are still unknown. This study aimed to investigate the cause of the BB's higher learning efficiency by analysing the variability of the children and the bicycles when learning, during the "Learning to Cycle" program. Participants were 23 children (6±1,2 years), divided into two training groups: BB (N=12) and BTW (N=11). Angular velocity data were obtained from inertial sensors (IMU) placed on the child and on the bicycle. Data while cycling was collected at three moments: i) before the program with the group's training bicycle (O1), ii) after six sessions with the same bicycle (O2), and iii), two months after the program, using a traditional bicycle (O3). Variability was assessed using the largest Lyapunov exponent. Results showed that the BB provided greater postural variability than the BTW during learning (O1 and O2), potentially leading to more adaptive responses when transitioning to the traditional bicycle (O3).

Keywords: Children; cycling; foundational movement skill; affordances; variability.

Resumo

Investigações recentes apontam a bicicleta de equilíbrio (BE) como mais eficiente para aprender que a bicicleta com rodas laterais de treino (BRL), mas as razões ainda não são conhecidas. Este estudo objetivou investigar a causa da maior eficiência da BE, analisando a variabilidade das crianças e das bicicletas ao longo do processo de aprendizagem, durante o programa *Learning to Cycle*. Participaram 23 crianças (6±1,2 anos), divididas em dois grupos de treino: BE (N=12) e BRL (N=11). Foram obtidos dados de velocidade angular através de sensores inerciais (IMU) colocados na criança e na bicicleta. A recolha de dados ocorreu em três momentos: i) antes do programa, com a bicicleta de treino do grupo (O1), ii) após seis sessões ainda com a mesma bicicleta (O2), e iii) dois meses após o programa, com uma bicicleta tradicional (O3). A variabilidade foi avaliada utilizando o maior expoente de Lyapunov. Os resultados revelaram que a BE proporcionou maior variabilidade postural que a BRL durante o processo de aprendizagem (O1 e O2), o que poderá ter levado a respostas mais adaptativas na transição para a bicicleta tradicional (O3).

Palavras-chave: Crianças; ciclar; habilidade motora fundacional; *affordances*; variabilidade.

INTRODUCTION

Cycling is a foundational skill with lifelong benefits, so its early learning should be encouraged (1). To learn how to cycle, several types of bicycles can be used. The most popular approach is using a bike with two lateral training wheels (BTW) (2). However, research has indicated this method as counterproductive due to the lack of representative design in the task (1). In contrast, a more recent approach, the balance bike (BB), has been considered the most efficient learning bicycle (3). This bike does not have extra wheels or pedals, which promotes balance exploration by the learner from first contact. Although there is relative consensus regarding the efficiency of the BB in learning to cycle, the reasons behind this are still not known.

Our hypothesis of the BB's learning effectiveness lies in the promotion of greater and functional movement variability during learning. Variability is a characteristic of the human movement system, which supports exploration of, and adaptation to, different motor solutions, with integrated and varied participation of different system elements (e.g., motor units, muscles, joints, limbs, movement axis and planes) to perform the intended task, adapting to the environment in which it is inserted (4). Functionality is assumed as the system's ability to carry out its functions or tasks effectively and efficient manner. Movement variability, as it explores different solutions for the same task, can contribute to task functionality, by affording system adaptability in facing unexpected and challenging situations (5). Variability can be assessed using nonlinear methods, in order to look for structure and quality of system variability (6). The largest Lyapunov exponent (LyE) is used to assess stability and variability, measuring the rate of how the orbits converge or diverge, with periodic signals equaling 0, a positive value signifying that the orbits are diverging, and a negative value indicating that the orbits are converging (6). The present study aimed to investigate the process of learning to cycle with the BB and BTW, comparing the variability observed (LyE): (i) within the same training bicycle group (BB or BTWs), (ii) between groups (BB vs. BTW) at different stages of acquisition, and (iii) between children who were and were not able to cycle independently after training.

METHODOLOGY

Study Design

The "Learning to Cycle" program (3) included two groups (BB and BTW), with six sessions using the training bicycles, followed by four sessions with a traditional bicycle (TB). Three evaluation moments were recorded: (i) before the program with a distinct training bicycle (O1), (ii) after six sessions still with the same training bicycle (O2), and (iii), two months after the program, with a TB (O3), see Figure 1.

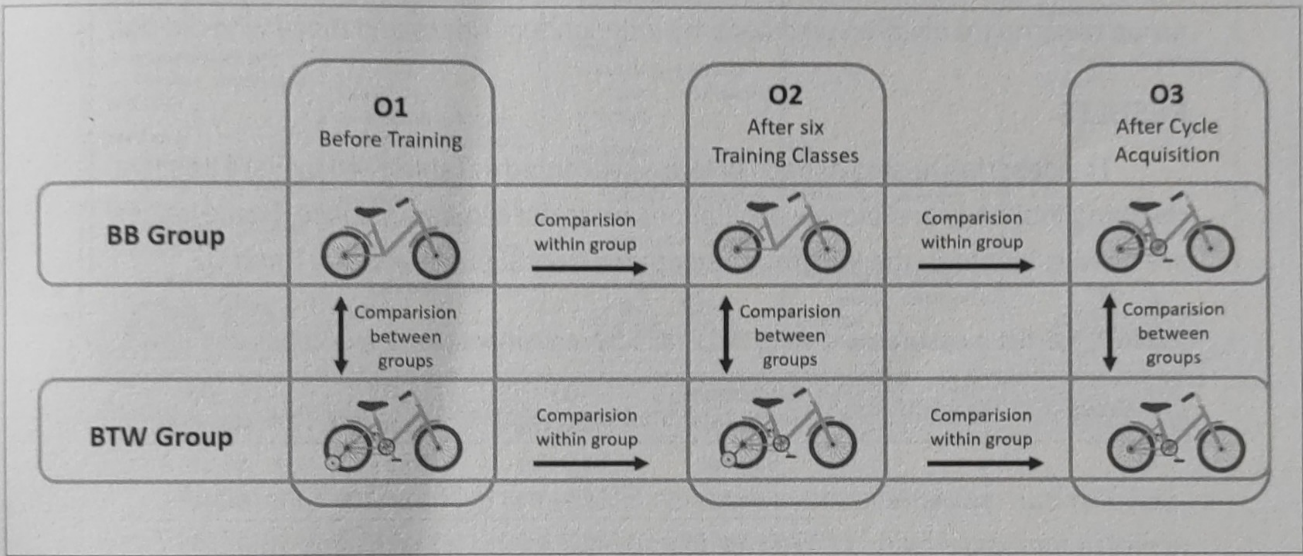

Figure 1. Study design's illustration.

Sample

Twenty-three children (nine ♀, 3-7 years, M=6±1.2 years), 12 in BB group (4 ♀) and 11 in BTW group (5 ♀). The groups did not differ in age, motor competence assessed by the Motor Competence Assessment (7) and body composition assessed by the body mass index's percentile. None of the participants were able to cycle independently with the TB before the program.

Data Collection

Children were invited to ride a bicycle (bicycle's group during O1 and O2, and TB in O3) for five minutes, in a 10mx10m landscape, with no verbal instructions or feedback. To capture data, four inertial measurement units (IMU) (SparkFun

9DoF Razor) were used (8), placed on the vertex and 2nd toracic vertebra (T2) of the children, and on the front wheel and frame of the bicycle.

Statistical Treatment

Data treatment was conducted with matlab and SPSS. The LyE values for angular velocity were calculated for each IMU, child and evaluation moment. For the statistical analysis, the three planes of motion of the children's data were considered, the frontal and transverse planes for the handlebars (recorded from front wheel IMU), and the frontal plane for the bicycle frame. Paired t-tests were used to compare, within the same group, the values of each IMU, by movement plane, between the different evaluation periods. Independent t-tests were used to compare between groups data from the same IMU by movement plane and evaluation, and in the BTW group to compare children who became independent riders and those who did not.

RESULTS

The descriptive data of each IMU are presented in Table 1. All LyE are positive, meaning that body and bicycle oscillations were not regular in space. These values are always higher in the BB group, except for frontal plane at the O1 and O2.

Table 1. Inertial measurement units (IMU) data by movement plane, evaluation and group.

Group	IMU	Movement Plane	O1 Mean±SD	O2 Mean±SD	O3 Mean±SD
BB	Vertex	Sagittal	58.8±1.5	59.3±1.0	58.5±1.4
		Frontal	57.9±1.1	57.7±0.9	56.6±1.3
		Transverse	56.5±1.3	56.9±1.0	55.6±1.7
	T2	Sagittal	59.2±1.5	58.5±1.2	57.3±1.0
		Frontal	56.6±1.3	56.3±0.8	55.4±1.3
		Transverse	57.4±0.8	57.2±0.7	56.2±1.6
	Frame	Frontal	54.3±1.3	55.2±0.7	55.9±0.9
	Handlebar	Frontal	56.0±1.1	57.3±1.1	57.6±1.5
		Transverse	55.8±1.1	57.2±1.1	57.7±1.7
BTW	Vertex	Sagittal	56.6±2.1	55.4±1.4	58.4±1.4
		Frontal	55.2±1.8	57.5±1.1	56.2±2.0
		Transverse	53.9±1.9	54.9±1.4	54.4±1.5
	T2	Sagittal	56.0±1.8	56.3±1.0	57.6±0.8
		Frontal	52.6±2.2	53.4±1.2	54.6±1.2
		Transverse	55.0±1.9	56.0±1.7	55.8±1.0
	Frame	Frontal	57.5±1.8	58.3±1.5	55.0±0.5
	Handlebar	Frontal	53.4±2.1	55.5±2.0	57.6±1.1
		Transverse	53.5±2.2	55.5±1.7	57.7±0.7

BB - Balance Bike; BTW - Bicycle with lateral Training Wheels; T2 - 2nd Toracic Vertebra

Significant differences were observed within the same group across evaluation periods (horizontal direction), as well as between groups for the same evaluation (vertical direction), which are presented in Figure 2.

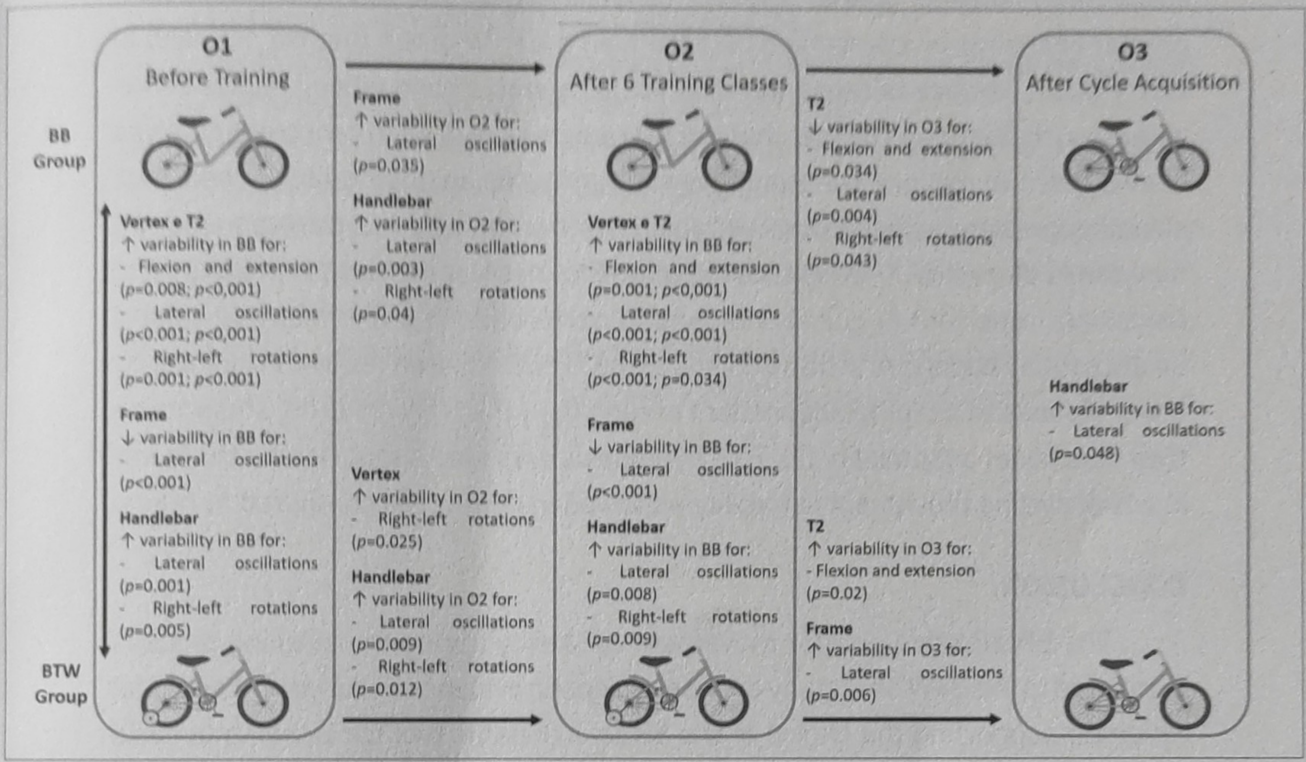

Figure 2. Differences found between evaluations and groups.

At the end of the program, all BB children successfully learned to cycle independently and became riders. Conversely, three BTW children did not achieve this skill and were considered non-riders (3). During O1, the three non-riders did not significantly differ from the other BTW children. However, at O2, children that became independent riders exhibited a higher level of variability in handlebar's lateral oscillations (p=0.002) and left-right rotations (p=0.002) than non-riders.

DISCUSSION

After the 6 training sessions, there was a significant increase in variability (LyE) in both groups, in the child and in the bicycle. This suggests that children were adjusting their posture and exploring more and faster oscillations. Interestingly, while the BB children increased their exploration of the bicycle oscillations between O1 and O2, the BTW children did not. When comparing O3 (in TB) with O2 (with training bicycle), the BB children reduced their variability in trunk velocity, probably to accommodate the task constraint imposed by the pedals. On the other hand, the BTW children increased the variability in both the trunk and bicycle, probably because after discarding the training wheels their support base was reduced and their center of gravity became less stable When comparing the two groups, the BB consistently revealed greater levels of variability (in O1 and O2). This group had a greater challenge in maintaining balance than the BTW group that did not need to worry about balance because the BTW remains stable even when children's feet do not touch the floor. The fact that the BB requires children to propel themselves allows them to explore various movement patterns, including lifting their feet, affording greater spatiotemporal variability in different body-bicycle segments and movement planes (8). This leads to higher LyE values (i.e., increased variability and flexibility), important to quickly respond to perturbations and effectively control balance (6), as happened in transitioning to the TB. BB children required significantly fewer lessons to acquire independent cycling than the BTW children, showcasing their functional adaptability (3). This hypothesis was also supported by the lower levels of cycling movement variability observed in non-riders compared to riders.

CONCLUSION

The BB afforded greater movement variability during the learning process compared to the BTW. This study provides scientific evidence and a clear theoretical rationale supporting the choice of the BB as a suitable tool for learning to cycle independently.

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