# A FIXED-GOAL TASKS (FGTT) CIRCUIT: A NEW TECHNIQUE TO ASSESS FOOTWEAR INFLUENCE ON CHILDREN'S LOCOMOTOR ABILITY

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**INTRODUCTION:** Footwear influences children's locomotor ability in several ways. This influence is the result of a complex interaction of design, mechanical properties, fitting and other factors. However, the different systems affecting locomotion control as well as walking patterns are in continuous development in children from birth up to maturity (Westcott, 1997; Pryde, 1997). As a result, the analysis of footwear influences on children's ambulation is very complex. It is often necessary to measure a great number of parameters, but instrumental techniques for gait evaluation used with adults are, in some cases, difficult to apply to children, who cannot bear long test sessions.

In this sense, simple, non-intrusive methods such as qualitative techniques would be more suitable for the study of footwear influences on children. Obstacle avoidance, balance and mobility tests have been widely used in biomechanics and physical therapy in this sense. Locomotor ability in children has been measured using simple obstacle circuits (Pryde, 1997), but few studies are known on children's footwear evaluation (Gould, 1985).

This paper presents a new obstacle circuit with fixed goal tasks (FGTT) which has been developed as a technique to assess the influence of footwear in children's ambulation and motor control skills. Results from the comparative analysis of three different boots are presented.

**METHODS:** A new technique based on a fixed goal tasks circuit (FGTT) was developed for the study of footwear influence on children's locomotor ability. Thirteen obstacles were placed along a circuit which included fixed goal tasks consisting of either single or complex movements children usually perform and which could be influenced by footwear. All the obstacles were similar in appearance and properties. The size and position of obstacles were set up, after several trials, for children wearing shoe sizes from 34 to 36. The obstacles were distributed in the following order from the start to the finish signals (Figure 1).

1. *Forward bar.* Walking forward on a wooden bar to study balance and feet positioning.
2. *Backward bar.* Walking backward on a wooden bar to analyze balance and the correct placement of the toecap in a complex movement of foot and leg.
3. *Normal* $\times$ *4*. Stepping over four consecutive obstacles of what was considered a normal height. This task was intended to analyze the automatic step.
4. *High 1.* This obstacle of great height was placed after a 90º change of direction. It allows us to analyze the correct perception of the toecap size and the influence of footwear weight on the control of movements to overcome the obstacle.
5. *Positioning.* Placing the foot on the diagonal of a box slightly bigger than the shoe to assess the maneuverability and the perception of the footwear size.

6. *Normal turn.* A normal height obstacle (*normal* $\times$ *4*) must be overcome at the same time that a 180º change of direction is performed. It was related to the co-ordination of both feet and to the medium-lateral movement of leg and foot.
7. *Double.* Two normal height obstacles placed consecutively. This obstacle allows us to analyze the mobility of the advance foot with a forced knee position at the same time as the support foot.
8. *High 2*. This obstacle is similar to number 4, *high 1*. This was included to analyze children's accommodation.
9. *High with hit*. This consisted of stepping over a high obstacle while kicking with the heel a second one which was slightly higher to analyze the accuracy of the ankle movement and the perception of the rear of the footwear.
10. *High with positioning*. In this obstacle the children had to perform *high 1* and *positioning* consecutively This task allowed us to study the complete leg movement, precision and perception.
11. *Upstairs*. Normal upstairs for studying the tripping risk.
12. *Cross stairs*. Walking upstairs crossing the legs to study the effect on lateral co-ordination and perception in the medium-lateral movement.
13. *Backward downstairs*. Walking backward downstairs to analyze the risk of falling due to toecap tripping or to incorrect functionality in sole flexion.

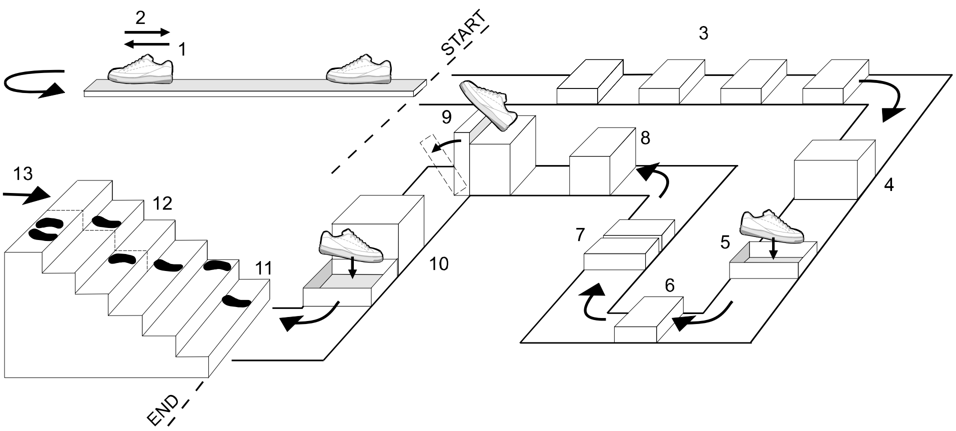


**Figure 1.** FGTT circuit.

The obstacles were placed along a path delimited by red marks on the floor with indications of the tasks the children had to do. The errors for each obstacle were visually quantified on a three-point scale: (0) no error, (1) small error and (3) large error. The time used for completing the circuit and the total number of errors were also recorded from each trial and stored for further analysis.

Descriptive statistics were used to study error frequency. Analysis of variance (ANOVA) and Non Parametric analysis of variance (Kruskal-Wallis) were done, considering the shoes as a factor to analyze footwear influence on time and total number of errors respectively.

Factor analysis of Principal Components was used to identify the association among most frequent errors. Analysis of variance was done considering children and shoes as factors to study the influence of both on error groups. Accommodation of children to walking conditions was analyzed by performing an analysis of variance of the errors and total time considering trial as a factor as well

as by comparing the frequency of errors in the obstacles *high 1* and *high 2*, which are the same but performed in different positions along the circuit. SPSS 7.5.2 and Statgraphics plus 2.1 for Windows were used for statistical analysis.
Seven healthy children (5 males and 2 females) aged from 7 to 10 years (mean of 8.4) participated in an experiment wearing three different trekking boots (size 35). The three boots differed slightly in the lacing system, dimensions and the soles. Before each test session, the fit of the boots was checked and the child was instructed about the circuit, allowing only one trial prior to testing. Each child performed three valid trials with each boot in random order, avoiding using the same boot in three consecutive trials to eliminate training effects. The children were carefully protected and the parents were informed in advance about the experiment and their written consent was first obtained.

**RESULTS AND DISCUSSION:** Non-statistically significant differences in the total time were found among the boots. The mean time was 36.25 seconds (sd=7.07). A high frequency of errors in many tasks was observed, which was considered as an indicator that the circuit really limited children's ability, forcing the performance of actions.
The table 1 shows the frequency of errors for each task. Only the obstacles with frequency of errors higher than 7.5 % (marked with asterisk in the table) were considered for the later analysis.

**Table 1.** Frequency of errors.

| Obstacle | Small error (%) | Large error (%) | Total |
|---|---|---|---|
| Forward bar (*) | 7.4 | 3.7 | 11.1 |
| Backward bar (*) | 16.7 | 48.1 | 64.8 |
| Normal x4 (*) | 0.0 | 16.7 | 16.7 |
| Position (*) | 3.7 | 5.6 | 9.3 |
| High 1 (*) | 9.3 | 3.7 | 13.0 |
| Normal turn (*) | 1.9 | 5.6 | 7.5 |
| Double | 0.0 | 0.0 | 0.0 |
| High 2 | 1.9 | 1.9 | 3.8 |
| High with hit (*) | 9.3 | 7.4 | 16.7 |
| High with positioning (*) | 22.2 | 9.3 | 31.5 |
| Upstairs | 0.0 | 0.0 | 0.0 |
| Cross stairs | 1.9 | 0.0 | 1.9 |
| Backward downstairs (*) | 3.7 | 20.4 | 24.1 |

The most frequent errors were related to backwards walking (b*ackward downstairs* and *backward bar)*; and to *high with positioning* obstacle. Simpler movements such as *normal x4*, *forward bar*, etc., also showed several errors.
The children showed quick adaptation to the boots and circuit. The first trial with a boot was always slower than the other two. The mean time was 41.54 seconds for the first trial and 34.67 and 32.54 seconds for the second and third respectively. Besides, the frequency of errors was reduced from 13.0% in *high 1* to 3.8% in *high 2*. There were no statistically significant differences in the number of errors for the different boots.
Factorial analysis yielded five error groups explaining the 73.9% of variance. These groups were as follows:

**F1**. High number of errors in *high with hit* and *high with positioning* and low number of errors on the *backward bar*. This was considered as bad perception of shoe size.
**F2**. High number of errors in *normal turn* and *forward bar*. These are related to forward movements with movements in the medium-lateral plane (from outside to inside). Related to shoe point.
**F3**. High number of errors in *normal x4* and *backward downstairs* and low number of errors on the *forward bar*. Influence on medium-lateral movements and shoe toe perception.
**F4**. This factor was mainly related to errors in *high with positioning*. Complex movement of the lower leg and the foot followed by precise positioning.
**F5**. Related to errors in *high 1*, first high obstacle on the circuit. Movement of simple elevation.
There were no significant differences among the boots for the 5 error groups. There were only significant differences among children for the error groups 3 and 4. That could be due to the fact that error groups would depend on the movements comprised by the different tasks rather than on footwear design, probably because the effect of wearing boots was greater that the differences among them.

**CONCLUSIONS:** The technique developed has proven to be useful for the analysis of locomotor ability in children as reflected by the high incidence and variety of errors. No differences were found among boots, probably due to the fact that the effect of wearing boots was greater than differences due to the different boots, in fact the error groups found were related to children's movements normally affected by boots (balance, toe perception, etc.). Children showed a very quick adaptation to the circuit and boots.
Qualitative methods based on fixed-goal tasks (FGTT) could be very useful for footwear analysis at different stages of children's development. New experiments with more different shoes could be encouraged to assess the power of this test.

**REFERENCES:**
Gould, N. (1985). Shoes versus Sneakers in Toddler Ambulation. *Foot & Ankle* **6**(2), 105-107.
Pryde, K. M., Roy, E. A., Patla, A. E. (1997). Age-Related Trends in Locomotor Ability and Obstacle Avoidance. *Human Movement Science* **16**, 507-516.
Westcott, S. L., Lowes L. P., Richardson P. K. (1997). Evaluation of Postural Stability in Children: Current Theories and Assessment Tools. *Physical Therapy* **77**(6), 629-645.

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