Preference in Girls' Lower Limb Tasks
女童對下肢動作的偏向

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Abstract

The research on laterality indicates that children become increasingly right preferent with age but these relate mainly to data on the upper limbs while lower limb preference is limited. This study investigated the direction of six lower limb preference tasks which included: kicking (stationary and moving ball); pick-up; step-up; balance and hopping. Fifty-one girls in the age group of 3, 4, 5 and 6 years were tested over four sessions at four monthly intervals and classified as right, left or mixed preferent after performing on two successive trials. This study hypothesized that girls would become increasingly right preferent with age and that lower limb preference would differ for each task. Data analysis used a three-way ANOVA repeated measures procedure with Age (4 levels) as the between subjects factor and Session (4 sessions) and Task (6 tasks) as the within subjects factors (N = 51). The ANOVA results showed two task groupings indicating that lower limb preference is task dependent. The authors proposed the interaction of individual differences, changing task and environmental demands influence the expression of lower limb preference.

Key Words: lower limb, direction of preference.

摘　要

偏向的研究顯示孩童隨著年齡的增長會逐漸向右邊偏向，但這些卻主要是針對上肢的研究資料，而對下肢偏向的資料卻有限。本報告探討六種下肢偏向的動作方向測試，其中包括：踢腿（定點和滾球）、拾起、踩踏、平衡和定點彈跳。五十一位三至六歲的女童參與四次測試，每次測試相隔四個月。在連續兩次嘗試後，將她們分類為向右偏向、向左偏向和綜合偏向。這項研究假設女童隨著年齡的增長，會逐漸有向右邊的偏向，對下肢的偏向會隨著動作的不同而有所改變。報告的資料分析使用了三項ANOVA 反復測量規程，以年齡 (4 個數值) 作為物件之間的因素，測試 (4 次測試)　和動作 (6 個動作) 作為物件之內的因素 (N = 51)。ANOVA 的結果呈現兩種動作類，顯示對於下肢的偏向是取決於動作的。作者提出看法，認為各個不同孩童的互動、動作和環境的轉換都對下肢偏向起著影響。

Introduction

Children and adults show lateral preferences in various tasks that involve the upper and lower limbs. When compared with the literature on preference in the upper limbs, lower limb preference has had less research attention. In general, the importance of research in laterality lies in the insight that such information could provide of the lateralised functions of the cerebral hemispheres. Given that there is less cultural pressure on the expression of lower limb preference (Gentry & Gabbard, 1995; MacNeilage, 1991; Peters, 1988), could studying lower limb preference provide a better understanding of the underlying neuromuscular control?

Since the literature on hand preference indicates that lateralisation is towards the right, can one expect similar right lower limb preference in young children? Further, is there an age band that can be identified for the establishment of lower limb preference and will lower limb preference change for different tasks?

Lower Limb Preference in Children

Research has shown that children use their right leg for kicking (Armitage & Larkin, 1993; Belmont & Birch, 1963; Gentry & Gabbard, 1995; Gesell, Halverson, Thompson, Frances, Castner, Ames & Amatruda, 1940). For example, Gesell and his colleagues reported that children aged three and seven years in Castner's (1935, cited in Gesell et al., 1940) study were right footed for kicking tasks but no age-related differences were shown in foot preference. These observations confirm other research in which right footedness was demonstrated by the children in the kicking task in a single session (Armitage & Larkin, 1993; Belmont & Birch, 1963).

In another children's study in which boys (n = 74) and girls (n = 74) aged between 5-years, 3 months and 12-years, 5 months were tested for a kicking task, Belmont and Birch (1963) reported that 85% (n = 125) were right footed, 12% (n = 17) were left footed and only 4% (n = 6) were mixed footed. Based on the results of the kicking task, Belmont and Birch (1963) concluded that over 95% of the children showed clear lateralisation of foot preference at an early age. The authors suggested that foot preference is established by the age of 5 years. In contrast to kicking, studies have shown a left preference for hopping (Larkin & Revie, 1995; Monson, 1990).

It appears that although individuals show right footedness, preference may also change according to the task performed (Armitage & Larkin, 1993). Armitage and Larkin (1993) reported that the percentages for the direction of preference for children varied for each task. The tasks were two trials for kicking a ball, pick up beads, and stepping onto a chair, forefoot tapping, repetitive hopping and static balance. This study revealed that normally coordinated children (5- to 6- and 8- to 9-year-olds) clearly established preference for the kicking task that corresponds with earlier research on kicking tasks (Belmont & Birch, 1963; Gesell et al., 1940). In addition, when forefoot tapping, repetitive hopping and static balance were added to the footedness test battery administered by Armitage and Larkin (1993), differences in percentages for each preference classification were shown.

Since studies have shown different lower limb preference response for different tasks (Armitage & Larkin, 1993; Monson, 1990), one is inclined to doubt that a kicking task can be generalised to the construct of footedness. In addition, could one task (kicking) be an accurate indicator of early lateralisation of the lower limbs?

Age and Mixed Lower limb Preference

A higher occurrence of mixed lower limb preference compared with mixed handedness has been reported (Didia & Nyenwe, 1988; Dodrill & Thoreson, 1993; Gabbard, 1992, 1993; Gentry & Gabbard, 1995). Gentry and Gabbard's (1995) study reported aged differences and mixed lower limb preference (N = 956 males and females). The tasks used were kicking a ball, stomping an imaginary bug and tracing letters with one foot while standing. Four and 8-year-olds showed similar preference response but were different from the older groups of 11-, 13-, 16- and 20-year-olds. The youngest groups (4- and 8-year-olds) were more mixed-footed. The overall percentage of mixed footedness was 19% while only 14% were mixed handed. Twenty-six percent of the younger 4- and 8-year-olds were mixed footed and 18% were mixed handed. The study, however, showed that the percentage response for right footedness parallelled that of right handedness in that the majority of the subjects in all age groups were right preferred. Right-footedness increased with age where 66% of the youngest group (4- to 8-year-olds) were right footed which increased to 81% for the 11- to 20-year-olds while mixed-footedness decreased from 26% (4- to 8-year-olds) to 13% (20 years, Gentry & Gabbard, 1995). Left preference was least common for the foot and hand tasks for all age groups. Similarly, Didia and Nyenwe (1988) reported that of the total number of children (N = 996) in their study, 28 were mixed footed and only 12 were mixed handed.

Gabbard and Bonfigli's (1987) study showed that 50% of the children were mixed-footed, 46% right-footed and only 4% were left-footed (N = 154, M Age = 53.5mths). Similarly, Armitage and Larkin (1993) reported that when the data for six preference tasks (kicking, pick up, step up, hopping, balance and tapping) were combined, mixed footedness increased for both 5- to 6- and 8- to 9-year-old normally coordinated groups (90% and 70% respectively). This increase in mixed footedness was due mainly to the balance and hopping tasks (Armitage & Larkin, 1993).

Thus far, the research shows that right foot preference increases with age (Gabbard, 1993; Gentry & Gabbard, 1995). A few studies, however, reported no age-related trend in foot preference (Didia & Nyenwe, 1988; Gabbard, 1993; Longoni & Orsini, 1988). Several reasons can account for the absence of the influence of age in lower limb preference which include the method used to test lateral preference, the sample size, the age interval and task used to test preference (Didia & Nyenwe, 1988; Gabbard, 1993; Longoni & Orsini, 1988).

Gender and Lower Limb Preference

Gender differences in lower limb preference responses have been shown by a number of studies (Didia & Nyenwe, 1988; Dodrill & Thoreson, 1993; Larkin & Revie, 1995 Whittington & Richards, 1987). Whittington and Richard's (1987) reported that girls showed a marginally higher right leg response compared to boys (Girls = 60.3%; Boys = 55.7%) while the reverse was shown for mixed preference (Boys = 36.8%; Girls = 34.2%) at age seven years. By age 11 years, the majority of children used their right leg to kick a ball but girls were more right preferent than boys (Girls = 91%; Boys = 86. 5%).

Didia and Nyenwe (1988) reported that the majority of children (N = 996, 5 to 12 years) were right footed for kicking but girls were more right footed (Boys: n = 443; Girls: n = 454) while a larger number of boys (Boys: n = 42; Girls: n = 29) were left footed for the same task.

In forward hopping, Larkin and Revie (1995) investigated the preference of boys (n = 193) and girls (n = 158) aged 5, 6 and 7 years. The authors reported that a higher percentage of 7 year old girls who preferred their left leg while the age-matched boys showed an increase right leg hopping.. The preference distribution for girls differed minimally compared with the boys. The percentages combined across the age groups showed 52% of girls preferred their right leg and 48% preferred their left leg for hopping. In comparison, 57% of the boys showed right preference and the remaining 43% were left preferred. These studies indicate that the distribution of lower limb preference for girls and boys are different depending on the task that children perform.

Theoretical Explanations for Lower Limb Preference

Studies have shown that the developmental pattern of lower limb preference is similar to handedness in that right lower limb preference increases with age (Belmont & Birch, 1963; Gentry & Gabbard, 1995). The similar developmental pattern of footedness and handedness is supported by research on cross indices in which foot and hand preference showed higher correspondence compared to eye and ear preference (Longoni & Orsini, 1988). This could be one reason why the theories used to explain the development of handedness have also been used to explain footedness. However, given that the research has shown that both children and adults show more mixed lower limb preference than mixed handedness (Didia & Nyuwe, 1988; Gabbard, 1992; Gentry & Gabbard, 1995), other researchers argue that the construct of lower limb preference is different to handedness (Gabbard, 1993; MacNeilage, 1991; Peters, 1990). What directs limb preference is still unclear (Annett, 1978, 1985; Geschwind, 1975; Kimura, 1971, 1982; Liepmann, 1980; MacNeilage, 1991; Previc, 1991; Stockmeyer, 1980).

If a similar increase in the prevalence of right lower limb preference is demonstrated in this study, could this then support predictions of a superior left cerebral hemisphere specialisation and contralateral motor control (Geschwind, 1975; Kimura, 1971, 1982; Liepmann, 1980; Stockmeyer, 1980). Such a theoretical proposition, however, is limited to a right preferent population as it does not explain the occurrence of left or mixed lower limb preference.

An explanation for left lower limb preference could be an ipsilateral control for postural support and left footedness where the left hemisphere controls the motor function of the left side of the body (Previc, 1991). MacNeilage's (1991) postural origin theory would predict that in humans, the right leg performs the operational function while the left leg provides postural support to this leg.

In contrast, the genetic theory proposed by Annett (1978, 1985) predicts that right preference is directed by an inherited Right-Shift gene. Left-handers, however, lack this gene which might lead them to be non-commital to the use of a right or left limb when performing a task. Underlying Annett's Right-Shift theory, therefore, is that environmental and cultural bias may direct limb preference (McManus, Sik, Cole, Mellon, Wong & Kloss, 1988). Bakan, Dibb and Reid (1973) argue that the incidence of left preference is the result of some neurological insult in the left hemisphere.

Supporting the view of multiple constraints on the development and stability of preference is the dynamical systems theory. This theory postulates that the development and establishment of preference is constrained by the individual, the task and the circumstances controlling the environment at a particular point in time (Carson, 1989; 1993; Newell, 1986). In addition, there is evidence to support the notion that different tasks may also influence the expression of footedness (Armitage & Larkin, 1993). Therefore, it appears that various theories can be used to predict the occurrence of right lower limb preference but none provide a clear explanation for mixed nor the incidence of left lower limb preference.

This study aimed to test the hypothesis that girls would become increasingly right preferred with age and across sessions. In addition, lower limb preference would differ for each task such that, for example, preference for hopping would differ from kicking task. This paper reports the findings for the direction of preference while the strength of preference is reported elsewhere (Nonis, Parker & Larkin, 2006b).

Method

Participants

Fifty-one girls aged 3 (n = 7, M Age = 39 months), 4 (n = 14, M Age = 49 months), 5 (n = 15, M Age = 61 months) and 6 (n = 15, M Age = 73 months) years volunteered in this study (Nonis, 1996; Nonis & Parker, 2005). Girls were placed in groups based on their age in which there was a six month age span for each group. Parental consent was obtained and cleared by the Human Rights Committee.

Procedure for Data Collection

Girls attended a familiarization session a week before the test session and were subsequently tested over a 16 month period at intervals of four months. One trained tester administered the test battery throughout the four sessions individually. Girls performed each lower limb preference task twice and rested for 2 to 3 minutes between trials (Nonis, 1996).

Lower Limb Preference Assessment and Statistical Analysis

Three footedness tasks (kick a stationary ball, step-up and pick-up) were selected from Porac and Coren's (1981) Laterality Test Battery while two other tasks; single leg static balance and repetitive hopping were from Armitage and Larkin's (1993) study. Kicking a moving ball was an addition to this test battery (see Appendix A).

The direction of preference was quantified by the trichotomous method which identified right, left and mixed preference in which the Laterality Quotient (LQ) was used. The scores for LQ ranged from -1 to +1. A negative value indicated a left biased preference and a positive value as right biased. When a child's score for the two trials were -1 and +1, she was categorised as mixed preferent (0) for the given task. A 100% cut-off criterion was used to define a child as right or left preferent (Armitage & Larkin, 1993; Longoni & Orsini, 1988)

The direction of preference was analysed using a three-way ANOVA repeated measures procedure with Age (4 levels) as the between subjects factor and Session (4 sessions) and Task (6 tasks) as the within subjects factors (N = 51). Post hoc contrasts using Student Newman-Keuls tests were used to identify task groupings. Post hoc tests were used to identify which means were significantly different. Although percentage of subjects for each age group and tasks for right, left and mixed preference was calculated for both within and across sessions, this paper reports the significant ANOVA results for the direction of preference while the strength of preference is reported elsewhere (Nonis, Larkin & Parker, 2006b). All statistical tests were considered significant at a probability of .05.

Results

Direction of Lower Limb Preference

The ANOVA results showed significant main effects for task [F (5,235) = 23.48, p < .01)] and session [(F (3,141) = 5.01, p < .01)] only. Student Newman-Keul's post hoc tests showed that there were task groupings (see Table 1). The tasks, kicking a stationary ball, kicking a moving ball and pick-up formed one group while step-up, balance and hopping tasks formed another group. Since preference scores ranged from –1 to +1 for right, left and mixed preference, the means showed that girls used their right leg for kicking both a stationary and moving ball and pick-up tasks (see Table 1). The direction of preference for step-up, balance and hopping tasks indicated shifts away from right preference towards increasing mixed preference. These results support the hypothesis that lower limb preference is task dependent.

Table 1. Means and Standard Deviations and Task Groupings* for the Direction of Preference of Tasks.**

Tasks	*M* (*SD*)	Groupings*
Kick Stationary Ball	0.83 (.46)	A
Kick Moving Ball	0.75 (.53)	A
Pick-up	0.64 (.50)	A
Step-up	0.18 (.70)	B
Balance	0.12 (.62)	B
Hop	0.09 (.74)	B

*Note.** Post hoc results using Student Newman-Keuls test, $p < .05$
** Score range: 1 (right preferent), -1 (left preferent) and 0 (mixed preferent).

Post hoc contrast for Session showed that the direction of preference at Session 1 differed from Sessions 2, 3 and 4 (see Table 2). Mean direction of preference, indicated that, irrespective of age and task, girls were more mixed preferent at Session 1 and shifted towards right preference at Session 2. Right preference was maintained at Sessions 3 and 4 (see Table 3). Given that there was a significant shift towards right preference between Sessions 1 and 2 only (see Tables 2 & 3), the hypothesis that girls will become right preferent as the sessions progressed is partially supported.

Table 2. Post Hoc Contrasts for Session Effect for the Direction of Lower Limb Preference.

Session Contrast	*Df*	*MS*	*F*	*p*
Session 1 & Session 2	1,47	39.28	5.96	.01*
Session 1 & Session 3	1,47	74.26	9.36	.00**
Session 1 & Session 4	1,47	60.74	7.2	.01*

Note. * Significant $p < .05$, ** Significant $p < .01$

Table 3. Means and Standard Deviations for the Direction* of Preference for Sessions (N = 51).

Session	M (SD)
Session 1	0.29 (.55)
Session 2 [a]	0.46 (.44)
Session 3 [b]	0.51 (.40)
Session 4 [c]	0.49 (.49)

Note. [abc]Significantly different from Session 1, $p < .01$
* Score range: 1 (right preferent), -1 (left preferent) and 0 (mixed preferent)

Discussion

Lower Limb Preference Changes to Task Groupings

This study supports the literature on task specific component relating to lower limb preference (Aglioti, Dall' Agnola, Girelli, & Marzi,1991; Armitage & Larkin, 1993, see Table 1). The results showed task groupings with kicking (stationary and moving ball) and pick-up tasks as one group and step-up, hop and balance task as another group.

Drawing from the hypothesis of different underlying neurofunctional demands (Vanden-Abeele 1980), it is suggested that kicking and pick-up tasks may share similar demands but are different to the step-up, hopping and balance tasks (see Table 1). It appeared that the pick-up task shared similar task characteristics to the kicking tasks in that girls had to use one leg to support their body weight (postural control) and the other to perform the actual task of picking the shell (operational action leg). In kicking tasks, the operational definition of the preferred leg is also used to perform the action of kicking the ball while the non-preferred leg provides postural support (Gabbard, 1989, 1993; Peters, 1988).

There are two implications of task groupings to lower limb preference. Firstly, that most girls establish preference for kicking at a young age of three years. The ANOVA results for the direction of preference shown in the present study support the cross-sectional data that children consistently use their right leg to kick both a stationary and moving ball (Armitage & Larkin, 1993; Belmont & Birch, 1963; Didia & Nyenwe, 1988; Gentry & Gabbard, 1995).

Secondly, although preference for kicking a stationary ball is established at age three years, when kicking was modified slightly to kicking a moving ball, overall there was a slight change in preference although the majority of girls still used their right leg for kicking (see Table 1). The idea that task difficulty can alter lower limb preference response reported in other studies is partially supported by the change in preference for kicking a moving ball task (Wilson, 1983). It is suggested that the older girls may have a more adaptable underlying neuromuscular control which allowed them to change their preference although age was not a factor in this study ($p > .05$). Since kicking tasks have commonly been used to define lower limb preference (Gabbard, 1989; Gabbard & Hart, 1993; Porac & Coren, 1981; Whittington & Richards, 1987), the slight change in preference for kicking a moving ball suggests that using a lower limb preference test battery would provide a better indicator of lower limb preference for different tasks.

Mixed Lower limb Preference

The phenomenon of mixed lower limb preference shown in other studies (Didia & Nyenwe, 1988; Gabbard, 1992, 1993; Gentry & Gabbard, 1995) was also demonstrated in this study. However, this study showed that the incidence of mixed preference was dependent on the task performed (see Table 1). This result is not surprising since Armitage and Larkin (1993) reported that mixed lower limb preference increased when the scores for three tasks of repetitive hopping, single leg balance and forefoot tapping were combined in the preference test battery based on a single session. Since individual task requirements for each of the lower limb preference items was different, it is not surprising that a different preference response was expressed for each task as indicated in the current study. Newell (1986) suggested that the boundaries set within a task and the individual's interpretation of such specific requirements will lead to an individual pattern of coordination. Although, there is constant interaction of the individual, the environment and task (Nonis & Parker, 2005), it is suggested that the latter task constraint had a significant bearing on the preference response both within (Nonis, 1996) and across sessions in the current study. The notion that task constraints may influence lower limb preference is not unlike Previc's (1991) suggestion that the choice of the limb used for postural control may be more dependent on the 'practical considerations' of the situation which allows for greater adaptability.

Drawing from Previc's (1991) notion of a neurofunctional definition of one limb that performs an antigravity flexion and the other an antigravity extension, the post hoc task analyses which showed that right foot kicking and pick-up tasks formed one group is expected (see Table 1). As suggested by Previc (1991) the antigravity extension and therefore postural control is usually provided by the left leg while the right leg performed the antigravity flexion and therefore the action leg. This antigravity flexion (action leg) was demonstrated by the predominantly right preference in kicking and pick-up tasks while the left leg performed an antigravity extension function and provided postural support to the action limb (Previc, 1991). However, if this notion of antigravity flexion and extension in which the left leg is usually the one that provides the postural support, is accepted, then one would have expected girls in all age groups use their left leg for the balance task. This was not the case. Instead, girls were mixed preferent across the four sessions (Nonis, 1996) for the balance task. It appears that although Previc's (1991) theory has support for the kicking and pick-up tasks, it does not explain why mixed preference was shown for the balance, hopping and step-up tasks.

Gabbard (1993) suggested that Annett's Right-Shift theory (1978, 1985) may explain the increased incidence of mixed lower limb preference. Annett's (1978, 1985) theory is not supported given that the results of the current study showed right preference in the kicking and pick-up and mixed preference for step-up, balance and hopping tasks. It appears that while genetics may explain the predominance of right preference in kicking tasks, the underlying neuro-functional demands (Peters, 1983; Vanden-Abeele, 1980) of the tasks is a more appropriate explanation for the changes in preference for the step-up, hopping and balancing tasks.

The result of mixed foot preference for static balance shown in the current study has little support for the theory that suggests a predominantly right hemispheric input to static balance control (Stockmeyer, 1980). What is more acceptable is the appropriate complementary interaction of both cerebral hemispheres based on the task demand as theorised by Stockmeyer (1980).

The difficulty of each lower limb preference task (Wilson, 1983) and the effect on postural control (MacNeilage, 1991; Peters, 1990) may be one reason why preference changed for some tasks. The performance of the lower limbs require a constant integration of postural change and balance (MacNeilage, 1991; Peters, 1983, 1990) and that as the complexity of the task increases, there is a possible trade off between the postural control limb which provides a stable platform from which the action can take place, and the action limb. In doing so, one could predict that task difficulty may affect girls who have poorer balance control to change preference with increasing difficulties in the task. However, one finds that the right preference in kicking would be predicted by MacNeilage's (1991) suggestion that the right leg is the operational leg while the left leg provides the postural support, it fails to explain the incidence of mixed preference in step-up, balance and hopping tasks. A follow-up study investigating the influence of balance control on lower limb preference in children is warranted.

Conclusion and Implications

The evidence provided in this study illustrated that the direction of girl's lower limb preference response varied according to the task performed. Girls showed that early lateralisation in kicking a stationary ball can be expected by the age of three years. In addition, girl's preference response was specific to the task groupings in that kicking a stationary and moving ball can be classified as one group and that lower limb preference

comparisons with other studies relating to such a task as kicking can be made with confidence. In contrast, step-up, hopping and balance tasks can be grouped together and separated from the kicking tasks. Given that the direction preference for step-up, hopping and balance tasks were different from kicking tasks suggests that combining preference scores for these three tasks with the kicking tasks would lead to incorrect interpretations of the development of lower limb preference.

A number of theories were explored to explain the expression of lower limb preference for different tasks in girls. The authors concluded that individual differences, the changing demands of both the task and the environment (in which the task is performed) could explain preference for different lower limb tasks (Nonis & Parker, 2005).

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Appendix A. Lower Limb Preference Assessment Procedure.

Lower Limb Preference Assessment Procedure

1. *Kick (Stationary ball)*. The child was instructed to position herself with her feet comfortably apart behind a soft ball (20cm diameter). The ball was placed in the center of a marked line and the child was asked to kick the ball towards the tester. If the ball slipped under the foot of the child, the trial was disregarded and repeated. A kick was accomplished when the toes of the foot came into contact with the ball. The preferred limb was defined as the limb that was used to kick the ball and the non-preferred limb provided the postural support while the task was performed.

2. *Kick (Moving ball)*. This task was similar to kicking a stationary ball with the exception that the ball was rolled to a midline position between the child's feet. In the event that the ball slipped or was biased towards either foot the trial was repeated. The limb used to kick the ball was recorded as the preferred limb and the non-preferred limb provided the postural support.

3. *Pick-up (Shells)*. The child stood in front of sea-shells which were arranged with the inner surface facing upwards so that it would be easy for the child to pick them up with her toes. A clear pick was when the child lifted her chosen limb to attempt to pick a shell. The preferred limb was the limb that attempted to pick the shells while the non-preferred limb provided postural support.

4. *Step-up (Bench)*. The child was asked to stand behind a marked line (10 cm) from a 30 cm high step up bench with her feet comfortably apart. When the child was balanced, on the command "and step up" she stepped on to the bench, turn around and jump off. A complete step up was when both feet were placed on the bench. The preferred limb was the limb used to step up on to the bench while the non-preferred limb provided the push off from the ground and postural support.

5. *Single Leg Balance*. The child was asked to balance for as long as she possibly could in a marked rectangular space (60 x 40 cm). She was asked to begin balancing on one leg on the command "ready and balance" with her arms positioned by her side. The timer was stopped when the child lost her balance control as indicated by the child (a) shifting at least one half of her foot from the original balanced position; (b) lifting the medial side of her foot and rolling onto the lateral edge or (c) touching the ground with her non-support foot. The preferred limb was the limb that was used to support the body weight and was in contact with the ground throughout balancing on a single leg. When the child rested and was ready, she was asked to perform the second trial.

6. *Hopping-in-place*. The child was asked to hop for as long as she could on the command "ready and hop" in a marked rectangular space (60 x 40cm). The preferred limb was defined as the limb used to support the body weight during hopping. The second trial was administered only after the child had rested and was ready to hop.

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1 This study formed part of the first author's doctoral studies in the Department of Human Movement and Exercise Science at the University of Western Australia.