FUNDAMENTAL MOVEMENT SKILLS AMONG FILIPINO CHILDREN WITH DOWN SYNDROME

Catherine M. Capio¹, Esmerita R. Rotor²

¹Institute of Human Performance, The University of Hong Kong, HONG KONG
²Department of Physical Therapy, College of Allied Medical Professions, University of the Philippines, PHILIPPINES

Impairments among individuals with Down syndrome (DS) include low muscle tone, decreased strength, poor postural control, and balance. Congenital heart defects and obesity are also common. In order to keep fit and prevent further complications, participation in physical activities is encouraged. Fundamental movement skills (FMS) are necessary in sports and physical activity participation. There is a research gap in the area of FMS development among children with DS, particularly for Asian populations. This study aimed to describe FMS among a sample of Filipino children with DS. A descriptive observational study was conducted using a standardized protocol and criterion-referenced assessment procedure. The following variables were investigated: overhand throwing, catching, standing long jump, kicking, and running. Each variable was analyzed in terms of body components. The participants were grouped into three age groups: 3–5, 6–8, and 9–12 years old. Data were analyzed using Kruskal-Wallis to test significant differences in the skills ratings of the age groups, with alpha level set at 0.05. The results showed significant differences in the skill components except leg-foot preparation and leg-foot action in kicking, arm preparation in catching, arm action in kicking, and arm preparation in standing long jump. The observed components that did not appear to have significant changes were related to balance and coordination deficits, as well as weakness of the trunk and legs. This may imply that physiotherapists need to address impairments in children with DS, focusing on coordination and balance problems as well as strengthening of trunk and legs. [J Exerc Sci Fit • Vol 8 • No 1 • 17–24 • 2010]

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Introduction

Infants and children with Down Syndrome (DS) have developmental motor delay associated with impairments such as low muscle tone, joint hyperextensibility, poor postural control, poor balance and, in some, congenital heart disease and obesity (Volman et al. 2007; Capone 2004; Palisano et al. 2001). In terms of motor development, it has also been shown that children with DS differ from typically developing children in the early years (Spanò et al. 1999). The characteristic impairments of the condition are also noted to lead to acquisition of fundamental motor skills (FMS) with compensatory movements (Block 1991).

FMS are considered the essential basis for the development of more advanced and specific motor skills, and are best learned during the prepubertal years (Payne & Isaacs 2002; Gallahue & Ozmun 1998). These skills are considered prerequisites to the performance of different forms of physical activity, such as sports and leisure activities (Okely & Booth 2004). FMS help children to develop control over their bodies, manipulate their environment, and form complex movement patterns involved in sports and recreation (Goodway & Branta 2003).
It is important that children with DS be exposed to physical activities early on in life, particularly because people with DS tend to adopt a sedentary lifestyle that is believed to be among the main factors contributing to their decreased levels of physical fitness (Dodd & Shields 2005). Recently, it has also been confirmed that obesity occurs more frequently among people with DS (Henderson et al. 2007). Physical activity is multidimensional and is perceived as important to children’s health and in controlling the problem of obesity (Ekelund et al. 2004; Metcalf et al. 2004). Its benefits cover the areas of health, socialization, discipline, and physical fitness (Winell & Burke 2005; Martens 1996; Sallis & Patrick 1994). In order to promote participation in physical activities, FMS should be developed well (Gabbard 2008; Goodway et al. 2003). Poor performance in these skills may be detrimental to the individual’s future participation levels.

**Motor skills development of children with DS**

The motor development of children with DS has been documented in the literature (Connolly et al. 1993; Block 1991; Connolly & Michael 1986; Anwar & Hermelin 1979). Studies have primarily been by recording the age when motor skills are attained, and walking is the milestone that has been reported most (Palisano et al. 2001). The emergence of motor milestones has been observed to have only a slight retardation, but the delays are heightened for the motor skills that develop later on (Vicari 2006). For instance, a pioneer study by Melyn and White (1973) documented that children with DS learn to walk within the age of 15 to 74 months. In comparison, typically developing children may walk earlier than 18 months.

Early on, the motor development deficits among children with DS have been associated with hypotonia (Harris 1981; Carr 1975). Although it has been suggested that children with DS attain their motor milestones in about the same sequence as their age-matched peers with typical development (Palisano et al. 2001), hypotonicity influences muscle co-contracting and balance reactions that lead to problems in postural control (Lauteslager et al. 1998). As such, atypical movement patterns have been reported which appear to aid the maintenance of postural stability (Vicari 2006). Furthermore, on a developmental perspective, it has been observed that weaknesses in motor skills and motor planning persist through age (Mon-Williams et al. 2001; Jobling 1999). Energy efficiency related to walking has also been shown to be lower than those of their typically developing peers, even at the preadolescent stage (Smith et al. 2007).

Particular studies focusing on FMS development in this population are limited. In a recent study by Volman et al. (2007), the examined variables included advanced motor skills. The study confirmed that children with DS have impairments in ball skills, manual dexterity and balance. A large interindividual variability in motor ability has also been observed. Such variability, particularly in ball skills, has been earlier demonstrated by Spanò et al. (1999), in a study that emphasized the need for individualized motor interventions. This current research contributes to the knowledge supporting our understanding of the motor development of children with DS. Focusing on FMS with a perspective on promotion of physical activity, this study examines the skills in terms of the detailed body components, in order to identify the factors that may promote skills development.

**Fundamental movement skills (FMS)**

There are two subgroups of FMS that are performed in an upright or bipedal position: locomotor, and object control skills (Burton & Miller 1998). Locomotor skills require overall movement of the body and may include running, galloping, hopping, leaping, jumping, and sliding (Foweather et al. 2008; Okely et al. 2004; Ulrich 2000). Object control skills, on the other hand, are more static in nature and cover ball striking, dribbling, kicking, catching, overhead throwing, and underhand rolling. FMS emerge as a result of many cooperating subsystems which may involve: (1) a specific task; (2) a learner with specific characteristics; and (3) a particular environment (Goodway & Branta 2003). This study aimed to characterize the FMS of children with DS while considering the first two cooperating subsystems. Emphasis is given to determining the component body actions where delay in FMS is mostly rooted from, in order to characterize the learner.

Specific to the current physiotherapy practice in the Philippines, the current chair of the Pediatric Special Interest Group of the Philippine Physical Therapy Association noted that there is no prevailing model in developing FMS among children with DS (R. Gandeza, personal communication, December 21, 2008). At the clinical practice level, the results of this research may provide a useful basis for development of practice patterns and individualized intervention programs for FMS training among children with DS in the Philippines. The findings are expected to have an impact on physical therapy treatment and physical education planning for the local population of children with DS, and thereby support the development of essential motor skills that are relevant in enhancing the physical activity of children with DS.
Methods

Research design
The study was approved by the Ethics Review Committee of the National Institutes of Health of the Philippines. Using a descriptive observational study design, the motor skills of the participants were assessed using a criterion-referenced protocol (Gallahue & Ozmun 1998). Performances of the motor skills were recorded on video and analyses were done using the standardized checklists for FMS. The following variables were measured: (1) overhand throwing; (2) catching; (3) standing long jump; (4) kicking; and (5) running. Each variable was further divided into body components, focusing on criteria for movement performance. Table 1 summarizes the variables and their components.

Participants
Using purposive, non-probability sampling, 33 Filipino children participated in this study. They were recruited according to the following criteria: (1) diagnosed with DS through genetic testing; (2) aged 3–11 years old; (3) able to ambulate independently; (4) can follow instructions with two-step commands; and (5) have not been diagnosed with associated medical complications where physical activity is contraindicated. Written informed consent was obtained from the parents of each participant prior to the start of the study. The participants were classified into three subgroups according to age: 3–5 years old (n = 10), 6–8 years old (n = 12), and 9–11 years old (n = 11).

Procedures
Prior to the actual data collection, two sets of pilot-testing were conducted: a technical pilot test and a procedural pilot test. The technical pilot test was conducted with three typically developing children in the same age group as the study sample. This testing established the placement of the cameras in each variable, distance between the camera and participant, and the placement of floor markers. The procedural pilot test was conducted with a group of three children with DS, one child per age subgroup. This step of the study verified that the target participants would be able to understand the instructions, and respond to the demands of the testing protocol. Interrater reliability for analysis was established between the two researchers who independently observed one participant per age group. The ratings were compared and statistical analysis showed high reliability (ICC = 0.9757).

Testing of the participants was conducted in two sites: (1) developmental therapy clinic for participants who were currently undergoing therapy; or (2) a special school for participants who were already attending primary school. Testing sessions were conducted on a designated day, separate from the participants’ scheduled therapy session or regular school days. The participants were asked to perform each skill in three trials. Instructions were given through two-step commands with demonstration. The details of the testing protocol are presented in Appendix 1. Digital video recordings were taken using two planes of reference: one for the lateral view and the other for the anterior/posterior views. These recordings were viewed by the two researchers, and the participants’ performances were evaluated against the criterion-referenced guidelines (Gallahue & Ozmun 1998) and recorded on a checklist. The checklist includes criteria for each body component of the variables, and the observed skills were rated from 0 to 3. A score of 0 meant that the component was absent, 1 indicated an initial stage, 2 meant the elementary stage, and 3 was given for the mature stage.

Table 1. Variables and components of fundamental movement skills (FMS)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Components</th>
</tr>
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<tbody>
<tr>
<td>Overhand throwing</td>
<td>Arm preparation Arm action Trunk preparation Trunk action Weight shifting Leg-foot preparation Leg-foot action</td>
</tr>
<tr>
<td>Catching</td>
<td>Arm preparation Arm action Hand preparation Hand action</td>
</tr>
<tr>
<td>Standing long jump</td>
<td>Arm preparation Arm action Trunk action Leg-hip preparation Leg-hip action take-off Leg-hip action flight Leg-hip action landing</td>
</tr>
<tr>
<td>Kicking</td>
<td>Trunk action Arm action Leg preparation Leg action</td>
</tr>
<tr>
<td>Running</td>
<td>Flight leg action (side) Stance leg action (side) Leg action during flight Arm action Leg action (rear)</td>
</tr>
</tbody>
</table>
Data analysis
The best performance in three trials was considered for data analysis. Since the scores from the performance of the skills were in ordinal scale, the median was determined for the body components in each sub-group of participants. Tests of significant differences were done between age groups using the Kruskal-Wallis test with the alpha level set at $p < 0.05$.

Results

Thirty-five participants passed the inclusion criteria. Two children were excluded due to inconsistencies in the date of birth as obtained from clinic records and as reported by the informant at the time of recruitment. The age range of the final sample was 3.1–11.07 years (mean age, 7.05 ± 2.5 years; Table 2).

Overhand throwing
The changes in overhand throwing components among our participants are illustrated in Figure 1. All the body components were in the initial stage for the 3–5 year age group. Arm and trunk movements developed to the elementary and mature phase in the 6–8 year and 9–11 year age groups. Weight shifting developed until the elementary phase. However, leg actions stayed in the initial phase in all the age groups. Statistically significant differences were observed among age groups in

Catching
All the four component body movements in catching were in the initial phase for the 3–5 year age group. Arm preparation, arm action, and hand preparation developed into the elementary stage in the 6–8 year age group. By the third age group (9–11 years), the components had reached the mature stage except for hand preparation, which remained in the elementary stage. This is shown in Figure 2. Statistically significant differences were observed in all but one component: arm preparation ($p = 0.07$).

Kicking
Figure 3 illustrates the development of kicking. All the components were in the initial stage for the youngest age group. In the second age group (6–8 years), leg preparation developed into the elementary stage. In the oldest age group, all the components reached mature stage. Nevertheless, differences were not statistically significant for arm action ($p = 0.078$).

Standing long jump
For standing long jump, all the components were in the initial phase for the 3–5 year age group, except for arm action and leg-hip landing, which were still absent. Leg-hip preparation, take-off, and flight had developed

Table 2. Variance and central tendency of the participants’ age ($N = 33$)

<table>
<thead>
<tr>
<th>Age during data collection</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.10</td>
<td>11.07</td>
<td>7.0630</td>
<td>2.50314</td>
</tr>
</tbody>
</table>

Fig. 1 Skills rating of overhand throwing components by age group. Statistically significant differences ($p < 0.05$) were observed among age groups for all the skill components except for leg-foot preparation ($p = 0.076$) and leg-foot action ($p = 0.929$).

Fig. 2 Skills rating of catching components by age group. Statistically significant differences ($p < 0.05$) were observed for all the skill components except for arm preparation ($p = 0.07$).
into the elementary phase in the next age group while all the other components were in the initial phase. Development continued in the 9–11 year age group, but only trunk action, leg-hip preparation, and leg-hip landing reached the mature phase. All the other components were still in the elementary phase (Figure 4). The age groups exhibited statistically significant differences in all the components except arm preparation ($p = 0.103$).

**Running**

Figure 5 illustrates the development of running. All the component body movements were in the initial phase for the 3–5 year age group. All these components developed to the elementary stage during the second age group. However, only leg action as observed from the rear continued to develop into the mature stage in the 9–11 year age group. The age groups showed statistically significant differences in all the skill components.

**Incidental finding**

Participants who were receiving physiotherapy intervention came from the age groups of 3–5 years and 6–8 years. In the 9–11 year age group, none were in physiotherapy programs during the time of data collection.

**Discussion**

In overhand throwing, leg-foot preparation and leg-foot action were observed to have remained in the initial phase of development for all the age groups. In comparison, components that required arm action reached the mature phase in the 9–11 year age group, while the components of trunk movements reached the elementary phase. The two components that were not observed to have changed required participants to perform a brief one-legged stance. There was an apparent problem with footwork when the arms and trunk were involved in simultaneous movement. This may be related to problems in balance, postural control and strength (Shumway-Cook & Woollacott 2001; Block 1991). When leg and foot movements are performed, the position of the line of gravity in the base of support is changed. This could be a cause for falls if the balance and lower extremity strength of the participant is impaired.
Catching is a multisegmental action that involves a reaching and grasping component (Jobling & Mon-Williams 2000). The results of this study show that all the components of catching changed significantly across the age groups except for arm preparation. Limitations of the study sample in catching may be related to problems in fine motor skills reported in children with DS. Bimanual coordination has been shown to be impaired and to have less developmental progress in this population (Spanò et al. 1999). Catching components require coordination along with timing at the precise moment that the oncoming ball reaches the participant. Savelbergh et al. (2000) noted that children with DS are not as successful in performing motor activities involving timing than their unimpaired peers. Furthermore, anatomical evidence reveals that the cerebellum of people with DS is disproportionately small in volume (Wu et al. 2008).

The arm action and trunk action components of kicking did not have significant differences between age groups, where they remained in the initial phase. Simultaneous arm and trunk action with leg action require coordination and maintenance of balance. Limitations in the participants’ ability to maintain their balance while performing the components may also explain the observations.

Not all the participants in the 3–5 year age group were able to perform a standing long jump. For those who were able to perform the skill, arm preparation did not change significantly. Standing long jump is a skill that requires strength of the lower extremities and trunk, as well as good balance to maintain the upright position upon landing. In the youngest age group of this study, the participants may not have adequate strength and good balance to perform the skill properly. The components were generally in the initial phase in the 6–8 year age group. In the oldest age group, only trunk action, leg-hip preparation and landing reached the mature phase. All the rest were in the elementary phase. Of the five skills that were tested in this study, standing long jump appears to develop later than the other skills. This may be attributed to its demands which include not only coordination and balance, but strength of the lower extremities as well.

Running was shown to change significantly among the age groups. However, four out of five components did not go beyond the elementary phase. This indicated that running components for this sample have not developed to the mature phase even in the oldest age group, implying a lag in the development of running. Furthermore, arm action had no significant changes. Arm movements result in perturbations of balance in the anteroposterior direction. Delay in the development of postural reactions of children with DS may explain this observation (Shumway-Cook & Woollacott 2001). The phase of single-support may require greater demands than their capacity to maintain their balance while moving.

The results of this study highlight the body components of FMS that do not change significantly over age. These imply the processes that may need interventions to promote adequate development of FMS among Filipino children with DS. The observed components that did not change with age were related to problems in coordination, balance, and strength of the trunk and legs. Maintenance of stability affects quality and accuracy in the performance of many skills and tasks. Balance being an integral part of movement, improvements here may assist in the development of FMS in the longer term (Foweather et al. 2008).

Previous studies on the same population also showed that the predominant problem areas across age groups in DS were response speed, tasks involving bilateral coordination, strength and especially tasks requiring postural balance (Jobling & Mon-Williams 2000; Connolly & Michael 1986). Even with an older population of children with DS, aged 10–16 years old, the attainment of proficient balance has been observed to be problematic (Jobling 1999). Consistent findings in coordination and balance may indicate a need to address these in the training of the FMS of this population.

A majority of the participants received physiotherapy, but it must be noted that at the time of this study, most of them were not receiving physiotherapy. All the participants in the 9–11 year age group were not in any form of physiotherapy. This is of interest as it is apparent that their FMS are not consistently in the mature levels. Training is necessary to develop these skills, and programs are required to address their problems in strength, balance, and coordination. In previous studies, it has been documented that this particular population has limitations in balance and coordination even in adolescence (Jobling 1999). The lack of appropriate intervention during the preadolescent stage may further contribute to the eventual limitations in attainment of motor proficiency. The local physiotherapy practice tends to discharge children with DS from physical therapy as soon as they are able to walk independently (R. Gandeza, personal communication, December 21, 2008). In view of the findings of this study, we may argue that the current local practice needs to be further evaluated and, possibly, changed.
The study design was descriptive, considering that the goal was to describe the changes in FMS among Filipino children with DS with increasing age. The expected applications are in terms of practice guidelines and treatment approaches. However, the descriptive study design limits the strength of the inferences on the causes of limitations in the FMS component skills. Further studies are recommended that can gather empirical data to explain the development of FMS components. The methodology may also be improved by using other standardized criterion-referenced tools in measuring FMS. Further studies to build on these findings may also utilize a between-subjects design to compare the skills of children with DS to a matched group of typically developing peers.

The study identified the FMS components that did not change with age groups, and implies that deficits in balance and coordination, as well as strength of the trunk and legs may be underlying the problem. This suggests that physiotherapists must continue to address impairments in children with DS, focusing on coordination and balance problems to prepare them with skills that will enable them to participate in sports and leisure activities with their peers. Strengthening of the trunk and the legs should also be included in the physiotherapy programs.

Acknowledgments

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References


### Appendix 1: Protocol for Testing Motor Skills

1. **Overhand throwing**
   - Equipment: ball (size of a softball)
   - Surface: non-skid
   - Area: at least 8 m²
   - Position of the video cameras: anterior and lateral views of the patient
   - Instructions: *When I say throw, throw the ball as far as you can. Ready, throw!*
   - Observations: If subject is able to perform the skill, proceed to the next skill. If not, repeat the instructions and perform a demonstration if necessary.

2. **Catching**
   - Equipment: ball (size of a softball)
   - Surface: non-skid
   - Area: at least 8 m²
   - Position of the video cameras: anterior and lateral views of the patient
   - Instructions: *Catch this ball when I throw it to you. Ready, catch!*
   - Observations: The examiner should throw the ball using an underhand pitch at the subject’s chest level. Any toss that is too low or too high should be disregarded. If the subject is able to perform the skill, proceed to the next skill. If not, repeat the instructions.

3. **Standing long jump**
   - Equipment: mat
   - Surface: soft with marker for the starting position
   - Area: at least 8 m²
   - Position of the video cameras: anterior and lateral views of the patient
   - Instructions: *When I say jump, jump with both feet as far as you can. Ready, jump!*
   - Observations: If subject is able to perform the skill, proceed to the next skill. If not, repeat the instructions and perform a demonstration if necessary.

4. **Kicking**
   - Equipment: ball (10–12 inches in diameter, smooth and minimal friction)
   - Surface: non-skid
   - Area: at least 8 m²
   - Position of the video cameras: anterior and lateral views of the patient
   - Instructions: *When I say kick, kick this ball as hard as you can. Ready, kick!*
   - Observations: If subject is able to perform the skill, proceed to the next skill. If not, repeat the instructions and perform a demonstration if necessary.

5. **Running**
   - Equipment: cones to mark the end of the run
   - Surface: non-skid
   - Area: at least 22 m × 32 m
   - Position of the video cameras: posterior and lateral views of the patient
   - Instructions: *When I say go, run as fast as you can to those cones. Ready, go!*
   - Observations: If subject is able to perform the skill, proceed to the next skill. If not, repeat the instructions and perform a demonstration if necessary.