HAY06512

Differences and similarities between the performance of a fundamental skill in gymnastics for three cohorts: Children, young adults and older adults.

John Haynes and Judith Miller
The University of New England
Ardidale NSW

Abstract
An examination of data for a basic skill taught in gymnastics, namely the forward roll, identified three sequences. These sequences were termed the beginning, bridging and end. Within each sequence a number of indicators were delineated, which were further subdivided into descriptors (Haynes, Miller, Callingham, & Pegg, 2005). This paper presents an analysis, using the descriptors as a means of comparison, for three cohorts: children, young adults and older adults (N = 117), who performed the forward roll. Results show both similarities and differences between each cohort. Findings are presented in graphical format, as well as in an ensuing discussion. There are pedagogical implications, especially for the way teachers/coaches engage their students from across different age groups.

Introduction
This paper emerged as part of a larger investigation into the applicability of existing assessment strategies, across a diverse age range of participants, for the forward roll. Data presented in this paper describe the movements of individuals, which through a process of deduction, led to the construction of the framework for assessing the quality of movement for the forward roll (Haynes et al., 2005). In addition, this paper presents an interpretation of the reasons for similarities and differences in the results, between cohorts whose ages range across the lifespan.

Method
One hundred and seventeen (N = 117) individuals, comprising three cohorts, namely, children whose ages ranged from 5 to 16 years, young adults aged between 18 years and 27 years of age, and older adults aged between 28 years and 50 years, were filmed using a digital video camera, whilst they performed a forward roll. These data were subsequently analysed to determine whether movement similarities were evident across cohorts.

Results
For the purposes of greater clarity three hypothesised sequences within the forward roll were proposed, namely the beginning, bridging and end. The beginning sequence commences when the participant stands at the edge of the gymnastic mat immediately prior to the roll, and ceases when the participant’s feet leave the surface. The bridging sequence includes the rotation of the participant’s body. The end
sequence begins at the end of the rotation and finishes when the participant rises to a standing position and/or the roll stops.

Analysis revealed that within each sequence the movement patterns and actions of the body appeared to be indicate particular quality levels. In addition, some body segments appear more critical for the performance of the roll than others. Examination of the three sequences led to a number of more detailed body configurations for each sequence. The rationale for the choice of the body positions, considered to be crucial to performance, includes the notion that a number of biomechanical principles need to be addressed in order to perform the roll in a skilled manner. The positions of various body segments, deemed essential to analysis are termed *indicators*, for the purposes of this study. Analysis led to the establishment of four *indicators* for the beginning sequence, two *indicators* for the bridging sequence and three *indicators* for the end sequence.

Further scrutiny of the *indicators* led to a further fine-grained description expressed in terms of *descriptors*. *Descriptors* provided an even more precise account of the limb and body position for all subjects.

The number and percentage of individuals displaying a particular *descriptor* for each indicator is contained in three Tables, which are presented in the following sections. In addition, the data for each cohort are shown in graphical format, one for each sequence, namely, the beginning sequence, bridging sequence and end sequence. Following each graphical Figure, an explanation of the results is offered in summary format.

**Section 1: Beginning sequence**

The number of individuals whose movements matched each beginning sequence *descriptor* within each *indicator* are presented in Table 1. These data are presented for each of the four *indicators*: hand position (*indicator* 1), arm/elbow flexion (*indicator* 2), head position on the surface (*indicator* 3), and the number of contact points (*indicator* 4). Note that the first listed *descriptor* for each sequence is the ideal position (highest quality) for each of the *indicators*. The work of (George, 1980) is employed in this determination.

<table>
<thead>
<tr>
<th>Indicator Number</th>
<th>Indicator Name</th>
<th>Descriptor and Code</th>
<th>Number of individuals in each cohort</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hands</td>
<td></td>
<td>Children (n=48)</td>
<td>Young adults (n=24)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11 (23%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shoulder width (sw)</td>
<td>14 (29%)</td>
<td>15 (63%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Close to shoulder width (c)</td>
<td>23 (48%)</td>
<td>7 (29%)</td>
</tr>
<tr>
<td>2</td>
<td>Arm/Elbow</td>
<td></td>
<td>8 (17%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Straight (st)</td>
<td>13 (27%)</td>
<td>18 (75%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bent back (bb)</td>
<td>27 (56%)</td>
<td>5 (21%)</td>
</tr>
<tr>
<td>3</td>
<td>Head</td>
<td></td>
<td>14 (29%)</td>
<td>8 (33%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No contact (nc)</td>
<td>13 (27%)</td>
<td>10 (42%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Back of head (ba)</td>
<td>21 (44%)</td>
<td>6 (25%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crown (top) of head (cr)</td>
<td>19 (41%)</td>
<td>9 (38%)</td>
</tr>
</tbody>
</table>
4 Number of Contact Points

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Two</td>
<td>4 (8%)</td>
<td>1 (4%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Four</td>
<td>19 (40%)</td>
<td>16 (67%)</td>
<td>22 (49%)</td>
</tr>
<tr>
<td>Three</td>
<td>3 (6%)</td>
<td>1 (4%)</td>
<td>5 (11%)</td>
</tr>
<tr>
<td>Five</td>
<td>22 (46%)</td>
<td>6 (25%)</td>
<td>15 (33%)</td>
</tr>
<tr>
<td>More than Six</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>3 (7%)</td>
</tr>
</tbody>
</table>

Note: The percentages are rounded to the nearest whole number, and those underlined, bolded and italicised indicate the highest value for each cohort. The same format also applies to Tables 2 and 3.

Across Cohort Comparisons: Beginning Sequence

The data depicted in Table 1, are presented in graphical format, for the beginning sequence of the forward roll in Figure 1.

---

**Figure 1: Beginning Sequence Indicators and Descriptors**

Figure 1 depicts graphs of the four indicators for the beginning sequence. Each graph shows a comparison between the descriptors. An attenuated explanation of the results, for this sequence, is offered in the following paragraphs.

Explanation for Beginning Sequence Performances

For the first indicator, namely, “Hand position,” shown in Graph 1(a), the children who displayed the highest quality descriptor were trained in gymnastics (Mauder, 2000). Those children who did not show the highest quality descriptor were generally lacking in experience as well as not possessing the physical qualities, such
as arm and shoulder strength, to perform in this way. Younger adults, who volunteered to perform the roll were physically capable of a high quality performance, but lacked the training to demonstrate refined movements. However, most were aware that the hands placed closer to shoulder width provided a solid base from which to commence the roll. When interviewed, young adults recalled previous learning experiences for this skill. Similarly, some older adults were aware that if hands were placed closer to the shoulders a better base of support was afforded.

The younger, and less experienced sub-group within the children’s cohort were concerned with losing balance and thus control (Packard, 2004; Wickstrom, 1983). Placing the hands very wide of shoulder width permits the head to be nearer the surface. Similarly, older adults expressed the desire to have the head as close to the surface as possible before rotation in an attempt to avoid sustaining an injury if control of the rotation was lost.

Graph 1(b) shows the “Arm/elbow position” indicator; this graph also reflects the dichotomous nature of the children’s cohort. Elite gymnasts, who are aware of the preferred biomechanical and aesthetic form and have been instructed to demonstrate this position, show the highest order descriptor in the children’s cohort. Whereas, children exhibiting a lower order performance descriptor are concerned with losing control because they are “top heavy as the head is large in proportion to the body” (Gallahue & Ozmun, 2002, p. 113). In addition, for some children their neuromuscular system may not be well developed (Tanner, 1978). Young adults indicated that they adopted a bent arm approach because of previous learning experiences. The elementary form of the roll was (and is) usually taught in the school setting by teachers, who usually teach the roll with arms bent (Department of Education Queensland, 1971). The young adult and older adult cohorts have similar reasons for adopting the bent elbow position. It is easier to lower the head to the surface with the elbows bent back than it is with the arms straight.

Graph 1(c) shows the descriptors for the indicator “Head contact,” and for the children’s cohort (29%) demonstrate a high quality performance descriptor, however, 44% use the crown (top of the head), as a pivot point, which may be due to an inability to support the body weight with the hands and arms. Once the arms are placed wider than shoulder width and the elbows are bent laterally to more than 90° the subject has no other biomechanically based option other than to place the top of the head on the surface. The dichotomous nature of the children’s sample (elite and beginners) also explains why many (who are older and more experienced) do not place the head on the surface. In contrast, the method of achieving ‘no’ head contact for young adults (33%), is different from that displayed by children, whereby the position of the arms/elbows permits the subject to allow the head to ‘slip through’ between the arms during the early part of the rotational movement. From previous learning experiences younger adults are well versed in the safety requirement of not placing the head on the surface and have the physical capacities, strength and coordination, to achieve the higher order descriptor. Fewer older adults have ‘no’ head contact as a possible result of waning strength (Shephard, 1998), or poor knowledge of technique, however, 42% in this sample of older adults placed the back of the head on the surface, rather than the top, thus some awareness of safety and “self preservation” self evident.
The descriptor termed the “Number of contact points” made with the surface at the commencement of the roll is shown in Graph 1(d). The slopes of the lines on this graph demonstrate a similar pattern for all cohorts. Descriptor 1 for this indicator requires a ‘flight phase’, which can be achieved with style and control, and only with a deep knowledge and sufficient skill of the gymnastics perspective relating to the requirements of a high quality forward roll. As such, 8% of this sample of children and 4% of younger adults achieved this quality of movement for this indicator.

A similar pattern of results emerges for descriptors 2 and 4, whereby all cohorts showed a similar percentage peak. This situation can be explained by two factors. Firstly, the ‘most’ common starting point for the roll (4 contact points) is hands and feet on the surface. This position provides a stable base of support for the commencement of the rotation. Secondly, the placement of the head on the surface provides stability (5 contact points) and in most cases extra support for a controlled stable launch into the rotation.

Three contact points (descriptor 3) implies that one leg is used to assist in the rotational aspect of the roll. If the subject is stationary with the hands and one foot on the surface, having the one leg being raised and moving can either provide momentum for rotation dynamically (Hay, 1978, p. 152) and/or permit the centre of gravity to be moved forward towards the head and over the hands (Schembri, 1983, p. 15). Both these scenarios permit the facilitation of rotation.

Six or more contact points, evidenced in 7% of the older adult cohort results from poor temporal planning, little movement conceptualisation, lack of kinaesthetic sense coupled with a apparent lack of sensory motor learning opportunities for this skill.

Section 2: Bridging Sequence

This section summarises the bridging sequence of the forward roll for each cohort. The bridging sequence was examined using the two indicators, the hip/knee and shoulder/arm positions. Table 2 shows the number of subjects from each cohort whose particular movements fit each descriptor.

<table>
<thead>
<tr>
<th>Indicator Number</th>
<th>Indicator Name</th>
<th>Descriptor and Code</th>
<th>Number of individuals in each cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Children (n=48)</td>
</tr>
<tr>
<td>1</td>
<td>Hip/Knee</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Straight bend contact (sbc)</td>
<td>20 (42%)</td>
<td>4 (17%)</td>
</tr>
<tr>
<td></td>
<td>Remain bent (bt)</td>
<td>11 (23%)</td>
<td>19 (79%)</td>
</tr>
<tr>
<td></td>
<td>Bend then straighten (bs)</td>
<td>3 (6%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td></td>
<td>Stay straight (ss)</td>
<td>14 (29%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>2</td>
<td>Shoulder/Arm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Straight arms 180°+ arc (as)</td>
<td>20 (42%)</td>
<td>10 (42%)</td>
</tr>
<tr>
<td></td>
<td>Arms bent, straighten (little impetus) (af)</td>
<td>8 (17%)</td>
<td>8 (33%)</td>
</tr>
<tr>
<td></td>
<td>Arms open to ‘V’ shape (av)</td>
<td>12 (25%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>Arms rotate with body may straighten (ar)</td>
<td>4 (8%)</td>
<td>6 (25%)</td>
</tr>
<tr>
<td></td>
<td>Arms rotate onto forearms (ae)</td>
<td>4 (8%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>
Table 2 presents a summary of the data, expressed in percentage terms, for the bridging sequence of the forward roll.

**Across Cohort Comparisons: Bridging Sequence**

The data depicted in Table 2, are presented in graphical format, for the bridging sequence of the forward roll in Figure 2.

**Figure 2: Bridging Sequence Indicators and Descriptors**

Figure 2 depicts graphs of the two indicators for the bridging sequence of the forward roll. Each graph shows a comparison between the descriptors. An explanation of the results, for this sequence, is summarised in the following paragraphs.

**Explanation for Beginning Sequence Performances**

The children, who demonstrated the highest order descriptor for “Hip/knee” position in Graph 2(a), are elite gymnasts showing the retention of previous learning. The younger adults and older adults, those who demonstrated this descriptor, revealed through interviews that they were involved in some form of gymnastic training during their youth.

The reasons for the wide difference in percentages, for the occurrence of descriptor 2, are, that the movement actions exhibited in the beginning sequence did not permit, in the case of the children, to be in a position to make and maintain a bent knee during rotation. In contrast, young adults and older adults were undoubtedly aware that ‘rolling into a small ball’ is the simplest position to adopt in order to maintain rotation. It is also probable that physical educators have taught this action, for reasons of safety, as part of elementary gymnastics lessons in schools. (Department of Education Queensland, 1971, p. 19)

Maintaining a straight leg position, or bending then straightening the legs, is a result of a lack of abdominal strength and an inability of the leg muscles to prevent the legs attempting to travel in a straight line due to centripetal forces (Hay, 1978, p. 163). Muscular strength and neuromuscular development are also major contributing
factors (Tanner, 1978). None of the younger adults or older adults presented this action.

In a similar way to the “Hip/knee” indicator, the “Shoulder/arm” position shown in Graph 2(b), the children who demonstrated descriptor 1 were well trained gymnasts. To achieve the straight-arm position and then rotate the arms forward in an arc requires kinaesthetic awareness, control and neuromuscular coordination. Older adults do not demonstrate similar percentages of this higher quality descriptor due to issues related to somatotype and other perturbances, such as reduced flexibility and body girth.

Descriptor 2 in which the arms straighten, but do not add any rotational force to the rotation, reveals an inability to coordinate the arms with the rest of the body in the rotational process, and is an attempt to move the centre of gravity forward over the base of support (the feet and buttocks) and to maintain momentum.

Abduction of the arms during the concluding stages of the rotation, particularly for this sample of children, was due to the attempt to implement the gymnastic ‘style’ taught during gymnastics coaching sessions. The opening of the arms into a wide ‘V’, rather than maintaining arm adduction, allows the less adept subject to maintain balance, in a similar way that a ‘tight rope’ walker uses their arms of a long bar to maintain balance.

The elbows remaining flexed throughout the beginning and middle section of the rotation and then extending, reflects the desire to control the rate of rotation, through the release of the degrees of freedom of the elbow joints. The additional impetus provided by arm thrust adds to the complexity of the rotation.

The arms remaining flexed at the elbows, followed by their placement on the surface, add to the stability of the performer by eliminating any sideways (lateral) movement.

Section 3: End Sequence

An outline of the data for all cohorts for the end sequence is examined using three indicators, the final leg movements, and the position of the feet at the conclusion of the rotation, and the final rotational movements made by the subjects. Each indicator has a number of descriptors. Table 3 shows the number of subjects who displayed each particular descriptor.

| Table 3: End Sequence of Leg, Feet Position and Final Movements for all Cohorts |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Indicator Number | Indicator Name | Descriptor and Code | Number of individuals in each cohort |                                      |
| (n=48) | (n=24) | (n=45) |                                      |
| 1 | Feet | Close to buttocks (cb) | 24 (50%) | 8 (33%) | 12 (27%) |
| 1 | Feet | Away from buttocks (ab) | 24 (50%) | 11 (46%) | 21 (46%) |
| 1 | Feet | Inconsistent (in) | 0 (0%) | 5 (21%) | 12 (27%) |
2 Final leg movements
   Together (lt) 20 (42%) 7 (29%) 8 (18%)
   Knees/feet apart (kfa) 16 (33%) 14 (58%) 16 (36%)
   Legs separated (ls) 12 (25%) 3 (13%) 21 (46%)

3 Final rotational movements
   Rising to standing unaided (ru) 18 (39%) 6 (25%) 1 (2%)
   Balance lost (lb) 6 (11%) 11 (49%) 5 (11%)
   Roll momentarily halts (sm) 4 (8%) 1 (4%) 1 (2%)
   Hands used to assist rising (uh) 8 (17%) 5 (21%) 29 (65%)
   Roll stopping completely (rs) 12 (25%) 1 (4%) 9 (20%)

The data depicted in Table 3, are shown in graphical format, for the beginning sequence of the forward roll in the following Figure 3.

Across Cohort Comparisons: End Sequence

As noted in Table 3 there are three indicators for the end sequence. The final two descriptors are a ‘compilation’ of movements, which have been grouped, based upon their similarities. For example, having the knees separated laterally and the feet together at the end of the roll, or the knees together and feet apart are regarded as having similar consequences for the participant.

Graph 3(a): Feet position
Graph 3(b): Final leg movements
Graph 3(c): Final rotational movements

Figure 3: End Sequence Indicators and Descriptors

AARE 2006
Figure 3 depicts graphs of the three indicators for the end sequence of the forward roll. Each graph shows a comparison between the descriptors. A précis of the results, for this sequence, is provided in the following paragraphs.

**Explanation for End Sequence Performances**

By way of explanation the difference between the percentages of each cohort exhibiting descriptor 1 for the indicator “Feet” position, shown in Graph 3(a), may be attributed to, firstly, the flexibility of the individual, as flexibility tends to decrease over time (Kendall & Kendall, 1948). Secondly, the bodily changes associated with increasing chronological age, such as increasing body mass (Gordon, Gonzalez-Mestre, & Garrett, 1992), e.g., increasing girth, reduces the capability of being able to place the feet close to the buttocks. Lastly, the children, all of whom are members of a gymnastics club, are taught to place the feet close to the buttocks.

Children who demonstrated the highest quality descriptor for “Final leg movements,” in Graph 3(b), were elite gymnasts. The majority of younger adults, separated the knees to achieve more ‘forward lean’ to assist with rising. By separating the knees the body is able to move forward and thereby shift the centre of gravity forward over the buttocks, i.e., moving the centre of gravity beyond the base of support. Older adults were more likely to cross the legs or separate the legs longitudinally to solve the problems of rotation and rising to a standing posture. Children with the knees or feet apart are also attempting to put the body in a better position to stand up.

For the “Combined final rotational movements” for each of the three cohorts shown in Graph 3(c), rising to stand unaided is associated with a high level of skill, and to some extent a leaner body type, and is more common in the children’s group. A number of younger adults (25) also exhibited this descriptor, which according to interview data, is associated with prior learning.

The loss of balance on rising to a standing position is due to over rotation. This is a result of having the legs in a tucked position (see bridging segment descriptor), which without good control, can cause increased rotational velocity (Hay, 1978, p. 288). This factor also contributes to the relatively low percentage of the young adult cohort who ceased to continue rolling during the end segment.

Of the older adults, 64% used the hands to apply force to the surface to assist rising to stand. This action is to ‘steady’ the body after the rotation and to apply sufficient force to allow forward and upward motion to continue. There are perturbances such as lack of flexibility, increased girth, which affect performance. In addition, insufficient velocity may be due to caution being exercised in the beginning and middle segments of the roll. These factors coupled with poor balance, may contribute to the action of using the hands to assist rising to a standing position.

**Conclusion**

Briefly, the observations were found to be useful for examining movement performance across a broad age range. This paper provided descriptions,
interpretations and discussion of the beginning, bridging and end sequences of the forward roll. The beginning sequence was analysed using hand position on the surface, the arm/elbow angle (flexion), the position of the head and number of starting contact points. The bridging sequence was examined using the hip/knee and shoulder/arm positions. The end sequence examined the leg movements, position of the feet and final movements.

For the beginning sequence the main similarities were:
- The hand positions between the children and the older adults.
- Arm/elbow positions for the beginning sequence of the young adults and the older adults.
- The number of contact points for both young and older adults

For the bridging sequence the main similarities were:
- Hip/knee positions of the young adults and older adults.
- The shoulder/arm descriptors for children and young adults.

For the end sequence the main similarities were:
- The feet position for all three cohorts.

Other findings were:
- For the beginning sequence the children’s cohort demonstrated the lowest quality movements for all four indicators. In contrast, this cohort demonstrated the highest quality for both the bridging and end sequence indicators.
- The young adults demonstrated the lowest quality for the bridging sequence.
- The older adults demonstrated the lowest quality for the end sequence.

Overall, the highest percentage for the descriptors for the children matched with the young adults once, and with the older adults twice. The young adults matched the older adults five times. There were two occasions where there was no match across the cohorts. There was one occasion where all descriptors matched across the cohorts.

A measure of movement quality, not previously catered for in forward roll assessment models, has been assembled using the data presented in this paper. This instrument was termed “A Model for Assessing Movement Quality of the Forward Roll” (MAMQ:FR) (Haynes et al., 2005). This instrument was subject to Racsh (1960) analysis. Further exploration, specifically with regard to the relationship between these qualitative findings and their application to a cognitive framework, specifically Biggs and Collis’ (1980) Structure of Observed Learning (SOLO) model is the next step to be undertaken in the larger investigation.

References.


