

## Mastery of rope skipping by first graders: Current status by sex and assessment criteria: an NW-CHILD study

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### Abstract:

**Introduction:** Rope skipping has health and developmental benefits, are used as part of physical fitness protocols and can also be used to identify deficits in general coordination skills of young children. No criteria are available to assess the mastery of rope skipping against, in the early grades. This study aimed to determine the mastery of rope jumping in first graders and also by sex and to provide assessment criteria that can be used to assess how well rope skipping is mastered. **Methods:** The study formed part of a stratified random sample of first graders that were selected in the Northwest Province of South Africa as part of the NW-CHILD longitudinal study, where one sub-region of the study was selected and 190 first graders (102 girls; 91 boys) with a mean age of 6.98 years were assessed on their mastery of rope skipping. Eight qualitative mastery criteria, based on the process, and quantitative mastering criteria, based on the product (number of correct jumps), were evaluated. Video recordings were made of the task and analysed afterwards. **Results:** Only one third of the group showed full mastery of the rope skipping task. The group demonstrates mastery above 50% in only two of the eight qualitative components, with considerable lower percentages of mastery in the other six components. Only 34.7% of the group fit the quantitative requirement of jumping five jumps in succession with rhythm while using both feet. Girls performed significantly better in all the qualitative and quantitative criteria, where more than 50% of the girls, and less than 20% of the boys, conform to the qualitative and quantitative requirements. **Conclusions:** It is concluded that rope skipping is a complex coordination skill that is not yet fully mastered by all first graders, with clear sex differences. More attention should be given to the mastering of rope skipping, and the assessment criteria that was developed within this study, can be used to evaluate the mastering of this skill. Developmental deficits that are identified by means of assessment can also be addressed by means of timeous intervention.

**Key words:** Rope jumping, Children, Gender differences, Health; Development; Qualitative; Quantitative; Body coordination;

### Public interest statement

Various health and developmental benefits are associated with rope skipping, while it is a cost effective and popular activity that are used in games and small spaces, and form part of Physical Education curriculums and fitness testing protocols. Very little is, however, known about what competency should be expected from school beginners in rope skipping. This study aimed to determine mastery of rope skipping in first graders, also by sex and to provide assessment criteria to assess rope skipping. Eight quality criteria and the number of jumps were evaluated in a randomized sample of first graders, 100 girls, 90 boys, aged 6.98 years, by means of video recording. Rope skipping was found to be a complex coordination skill that is not yet fully mastered by first graders, with significantly better mastery in girls. The assessment criteria that was developed can be used to determine mastering and improvement of rope skipping skills based on the assessment outcome.

### Introduction

Rope skipping is a widely-used and favoured activity by young children and performed as a fun activity on playgrounds at schools, during Physical Education classes or in limited spaces, while it is also included in fitness protocols and healthy heart challenges (Zhu, Yang, Kong, Zang & Zhuang, 2017; Nebahat & Acar, 2018; American Heart Association, 2021). Rope skipping has also developed from a joyful pastime activity of children to a worldwide competitive sport (Engelbrecht, 2004). Various health and developmental benefits of rope skipping are reported for children (Lee, 2010; Ha & Ng, 2017; Zhu et al., 2017; Nehehat & Acar, 2018, Albers & Lewis, 2020; Johnstone, 2020). It is reported to be an effective mode of exercise while positively impacting fitness, body composition and bone health (Ha & Ng, 2017, Nebahat & Acar, 2018; Albers & Lewis, 2020). Other advantages include improvements in dynamic balance, explosive power, speed, agility, timing and rhythm, and coordination (Lee, 2010; Treccori Cavaggioni, Caccia, & Alberti, 2015; Nehehat & Acar, 2018, Johnstone, 2020). Confidence is also built when the rhythm and timing of the rope skipping action is mastered (Johnstone,

2020). In addition to the mentioned advantages, Cardoso and Magalhaes (2009) is of the opinion that skills such as rope skipping and star jumps can be used to identify motor problems in young children as such skills depends on overall body coordination, bilateral integration and motor planning abilities.

The *American Heart Association* (2021) recommends that school children should participate in rope skipping activities due to the health benefits of such activities. The Document Curriculum and Assessment Policy Statement (CAPS) (2011) of South African schools list skipping ropes as standard equipment in schools and rope skipping as a specific skill outcome of the Life Orientation learning area in Foundation Phase (grades R – 3) teaching. A rope skipping test is also included in the 2014 revised Chinese National Student Physical Fitness Standard (CNSPFS) to provide estimates of 9-12-year-old school-aged children meeting physical fitness standards (Zhu et al., 2017). Although rope skipping is considered to be an important basic skill to be mastered by young children, the execution of this skill requires advanced movements that develop with age, and, which is in all probability, not yet mastered fully by seven year-old children (Cardoso & Magalhaes, 2009). It is therefore important to understand what skills make-up are required from young children at specific ages that will enable them to jump rope successfully. Such knowledge can aid understanding of age appropriate competence in this skill, and hence shortcomings or deficits in acquiring the skill of rope jumping.

Rope skipping is a complex fundamental motor skill that requires the rotation of a rope with the arms around the body and repeated bouncing with both feet, approximately 3.3 cm apart. When the skipping rope is pulled in motion over the head, a plyometric jump has to be simultaneously performed in order to jump over the rope, suggesting the success of the jumping action depends on the mastering of two-legged jumping, that adds to the complexity of mastering this skill at a young age. The aim with the jump is to maintain constant vertical take-off and landing phases of between 3 and 5 cm to let the rope pass below the feet until the end of the exercise (Nebahat & Acar, 2018). During successive jumps the body needs to re-establish balance and propulsion force through a coordinated action of upper and lower region muscles where balancing abilities are essential to obtain an effective pushing phase (Trecroci et al., 2015). Good upright posture to maintain body stability, gross body coordination (integrity of the sensory and motor systems in a congruent and harmonic pattern) and rhythm are therefore essential requirements for rope skipping (Falola, Gouthon and Amusa, 2008, Trecroci et al., 2015). To add to this complexity, external rhythm is also essential because the jumping action should be rhythmically coordinated with the swinging-action of the rope which is an external object. Rhythm is described as the synchronised scheduling of a chain of events in time which is critically important in the execution of any action in a coordinated manner. Two specific motor abilities are furthermore also required in rope skipping, namely *bilateral integration*, which is the simultaneous use of both sides of the body to achieve a smooth and coordinated movement, and *motor sequencing* that entails the planning and production of sequenced actions (Cardoso & Magalhaes, 2009).

As the development of rope jumping is considered to be an important goal to achieve in young children, the mastering of rope jumping at a young age should be analysed in a comprehensive way, which includes a qualitative and quantitative assessment approach (Miller, Vine & Larkin, 2007; Capio, Cindy, Sit, Eguia, Abernethy and Masters, 2013). Researchers (Charlop & Atwell, 1980; Payne & Isaacs, 2017) are of the opinion that it frequently happens that a child's movement skills adhere to quantitative age norms, but that proper qualitative execution (precision or accuracy) of the skill are lacking. Payne and Isaacs (2017) and Gallahue, Ozmun and Goodway (2012) furthermore mention that especially the qualitative execution and hence the refinement of fundamental movements to advanced levels in the early childhood years can be delayed if incorrect methods or techniques are learned. For qualitative assessments, measuring instruments that comprises a subset of criteria which can be employed to analyse the technique or motor pattern that is required, are needed while measuring instruments which are based on norms are employed to assess and compare an individual's skills to others of similar age, gender and socio-economic groups in quantitative analyses (Payne & Isaacs, 2017). However, limited literature could be found on the qualitative and quantitative execution requirements of the rope skipping action in typical seven-year-old children. Researchers only reports that five year-old children should show mastery of rope jumping although no qualitative or quantitative guidelines are provided for this assertion. Tse, Fong, Wong and Masters (2017) included 5- to 7-year -olds in their recent study and report two successful consecutive skips and a mean score of 3 out of a possible 9 in a qualitative assessment of rope skipping in children between 5 and 7-years of age. The influence of gender on the ability to master rope jumping at a young age is, however, also not clear and only a few studies report on such differences at early ages. Pienaar, van Reenen and Weber (2016) report full mastery in 23.1 % of the group and clear sex related differences of 13.3%, where 11.42% of boys and 35.13% of girls respectively at 6.3-years showed full mastery of rope skipping. In older children, Zhu and co-workers report no gender effects on rope skipping in approximately 9-year-old children, while the study of Ha, Wong, Chan and Fishburne (2006) found that 9 to 11 and 12 to 14-year-olds girls outperformed boys in the number of rope skips performed within 30 seconds. In a Chinese study of fitness standards of eight-year-old children (N=89,949), boys were able to perform 83 jumps in one minute compared to 95 jumps in girls (Zhu et al., 2017). Another recent study also confirms gender differences in rope skipping ability and mainly attribute these differences to play preferences, where girls are found to be more interested in rope skipping activities (Resaland, Aadland, Andersen, Bartholomew, Anderssen & Moe, 2019). In agreement, Micallef, Calleja and Decelis (2010) report rope skipping as an activity of choice for 67.5% children

with a mean age of 11.5 years of which 47% were boys and 88%, girls. Fifty-seven percent of the boys, however, viewed rope skipping is an activity meant for girls. Ackerley (2003) also report that the popularity of rope skipping, among boys deteriorate over time as team sports activities become more popular in this gender. It therefore seems that sex specific differences become clearer at older ages, and mainly as a result of changes in the popularity of the activity as children get older.

It is clear from the literature that rope skipping has various developmental and health benefits but it is a complex coordination skill for young school children to master. Rope skipping also shows potential for use by movement specialists who can employ it to identify and address coordination related problems associated with overall body coordination, bilateral integration and motor sequencing. However, before rope skipping can be used for this purposes amongst first graders that are in the age group 6 to 7-years, more knowledge about the complexities of rope skipping as a skill is required in this age group. This includes knowledge about both the qualitative and quantitative aspects of rope jumping, and whether boys and girls in this age group will have the same developmental level of competency in rope skipping. The objectives of this study were therefore twofold. Firstly, to determine the level of mastery of different qualitative and quantitative mastering criteria of rope skipping of boys and girls in their first grade and secondly to provide an assessment criterion that can be used in young children that are accompanied by age appropriate descriptors of mastery levels. We hypothesised that 50% of the first graders will have mastered the skill of rope skipping on both a qualitative and quantitative level, and that the rope skipping abilities of girls will be superior to that of boys.

## **Methodology**

### **Research design**

A cross-sectional analysis within a longitudinal research design was used in this study. Grade 1 children in the North-West Province of South Africa, who were part of the baseline measurements of the NW-CHILD longitudinal study (2010-2016), served as the target population for this study. A stratified random sample was drawn from twenty schools and 816 grade 1-children (412 boys and 394 girls) were tested in this study. The children were selected by means of stratified random sampling. A list of schools in the North West Province was obtained from the Department of Basic Education in order to identify participants. This list of schools is grouped into eight educational districts which contains between 12 and 22 regions with approximately 20 schools per region each (minimum of 12, maximum 47). Using this list, a representative sample per region and schools was randomly drawn pertaining to population density and the quintile status of the schools. Girls and boys in grade 1 were further selected randomly within each selected school. Twenty schools, with a minimum of 40 children per school, equally distributed between genders and quintile status of the schools, were entered into the research project. Only a subsample of the total group of children that was part of the NW-CHILD study, namely one region, was selected for the purpose of this study.

### **Research group**

One of the four school regions that formed part of the NW-CHILD study was randomly selected for the purpose of this study. One hundred and ninety-three subjects (91 boys, 102 girls), with a mean age of 6.98 year, from five schools in the Delareyville school district, were assessed with regard to their rope skipping skills. The group consisted of 6 and 7-year-old children (6-year-olds,  $n = 83$ ; 36 boys, 47 girls; 7-year-olds,  $n = 110$ , 48 boys, 62 girls). Three children had incomplete datasets and had to be omitted for the final analysis. The final group included 190 subjects, 90 boys and 100 girls.

### **Ethical approval**

Ethical approval was obtained from the HREC committee of the North-West University (NWU-0070-09-A1). In addition, permission was obtained from all the headmasters of the different schools, and parental consent and child assent had to be provided before a child could take part in the study.

### **Measuring instruments**

#### **Rope skipping: Qualitative assessment criteria**

An intra-task evaluation of the rope skipping technique which is used to judge rope skipping as a sport was used (Falola et al., 2008). This criterion was further refined according to the descriptors by Bibaud (2008) to determine and describe the qualitative criteria that are required for rope skipping and to assess the execution accordingly. This compiled list of criteria describes the positions and actions of the rope skipping skill in eight technical execution steps.

1. Starting position with rope hanging behind the body at the ankles.
2. The rope should be gripped with the palms facing forward and the thumbs sideways-upward at the start.
3. A clear backward-upward swing of the rope behind the body.
4. A straight body and head posture to observe the rope at eye level when passing over the head.
5. A clear forward-downswing of the rope in front of the body.
6. The jumping action to clear the rope should be started with both feet simultaneously.
7. The jumping action should be with knees slightly bent while landing on the ball of the feet.
8. Rope should slide across the floor while clearing the rope.

A three-point Likert-scale (0-2) was used to assess the eight technical aspects of the task analysis on a scale of zero to two with regard to the *quality* of the execution. Zero (0) indicated no mastering of the technical aspect that was assessed, one (1) indicated partial mastering, although errors are prevalent, and a score of two (2) indicated good or mature mastering of the skill. A total score of 16 could be achieved in the analysis of the qualitative or technical mastering of the skill.

#### **Rope skipping: Quantitative assessment criteria**

Quantitative mastering was measured by assessing two criteria: (1) the subjects' ability to execute five rope skips in succession, jumping with both feet simultaneously, and while using a full revolution of the rope during the jumping and, (2) whether these jumps could be performed rhythmically without any stopping in between. The same three-point Likert-scale criteria as for the qualitative mastering, was used and a total score of four could be achieved.

The qualitative (16) and quantitative (4) scores are added to determine **a total score out of 20**. A child could thus achieve a maximum total of 20 (16 qualitative; 4 quantitative), where a score of 20 is indicative of full mastery of rope skipping on a quantitative and qualitative level.

#### **Video analysis**

A Sony Handycam DCR-SR67E video camera was used to record the rope skipping of each child in order to analyse it afterwards in detail. A child was able to choose between two different lengths of skipping ropes (1.80 meters and 2.0 meters), depending on the length of the child. The correct way to execute the rope skipping skill five times rhythmically, while jumping with both feet simultaneously, was firstly demonstrated to the child. Trained translators were used to explain the task to the child when they he or she did not understand what was required from them. Following the demonstration, the execution of the rope skipping skill of each participant was recorded with the video camera. Each participant was firstly recorded from the front in order to clearly observe the subject number, where after the participant was recorded from the side from where the technical execution could be better observed. This video analysis was then used afterwards to assess the rope skipping skill qualitatively and quantitatively while sitting in a quiet room.

Four Kinderkinetics post-graduate students and one senior researcher assessed the rope skipping skill. All researchers first attended a training session and participated in a pilot study where they viewed video material of children who were rope skipping. The researchers had to apply the selected criteria to the video material and independently assess each of the children. The marks awarded were individually discussed with the senior researcher and any uncertainties were eliminated. The four researchers thereafter, independently assessed each participant according to the set criteria in the presence of the senior researcher. The video material was, when required, replayed several times to ensure that the researchers categorised the participant in the correct category of mastery. The test-retest reliability of the researchers was determined by selecting ten subjects randomly who were re-evaluated one week after the first assessment took place. The following indices for inter-test invigilator reliability were recorded ( $r = 0.95$  for the total score out of 20),  $r = 0.99$ ; for the quantitative mark out of 4:  $r = 0.93$  for the qualitative total out of 16). All indices fall within the acceptable levels of reliability.

#### **Statistical analysis**

Statistica for Windows (2015) was used to analyse the data. A correlation coefficient was firstly performed to determine the test-retest reliability of all the examiners. In addition, normal distribution curves, frequency distributions and percentages were used to analyse percentages of mastery of each of the qualitative and quantitative criteria of rope skipping. An independent t-test and frequency tables were used to determine sex differences in rope skipping. A p-value smaller than 0.05 was used to identify significant sex differences. Effect sizes were also calculated to evaluate the practical significance of differences ( $d \geq 0.2$  small,  $d \geq 0.5$  medium,  $d \geq 0.8$  large) (Cohen, 1988).

#### **Results**

This study aimed to determine the mastery of rope jumping in first graders and also by sex and to provide assessment criteria that can be used to assess how well rope skipping is mastered. The data were firstly analysed to determine the normal distribution of the data. A satisfactory distribution curve was found which indicated that parametric statistics can be used to analyse the data. Table 1 shows the percentage qualitative mastering of the group ( $N=190$ ) in each of the eight qualitative sub-criteria of rope skipping, as displayed as no mastery, partial mastery and good mastery. Only two of the eight sub-criteria showed good mastering (2) at a level higher than 50% in the group, namely the starting position with the rope behind the body at the ankles (63.16%) and using the correct grip on the rope with the palms facing the front with the thumbs on top during the starting position (64.21%). The other six sub-criteria differentiated between complete mastery (2), ranging between 9.47% and 43.68%. The jumping action where the rope is cleared with slightly bent knees on the ball of the feet showed the lowest mastery percentages (9.47%), while the largest percentage of the group were categorised in the no mastery (0) group (48.95%). The swinging action of the rope behind and in front of the body, and the body posture during this part of rope skipping showed only 22% and 25% complete mastering, respectively.

**Table 1: Percentage qualitative mastery of the sub-components of rope skipping (N=190)**

| Qualitative criteria                                                                             | No Mastery |       | Partial Mastery |       | Good Mastery |       |
|--------------------------------------------------------------------------------------------------|------------|-------|-----------------|-------|--------------|-------|
|                                                                                                  | N          | %     | N               | %     | N            | %     |
| 1. Starting position with rope behind the body at the ankles                                     | 11         | 5.29  | 59              | 31.05 | 120          | 63.16 |
| 2. Grip on rope: palms facing forward, thumbs sideways                                           | 46         | 24.21 | 22              | 11.58 | 122          | 64.21 |
| 3. Backward-upward swing of the rope behind the body                                             | 61         | 32.11 | 87              | 45.79 | 42           | 22.11 |
| 4. Head aligned with straight upper body, observe rope at eye level when it passes over the head | 38         | 20.00 | 108             | 56.84 | 44           | 23.16 |
| 5. Forward and downward swing in front of the body                                               | 1          | 0.53  | 141             | 74.21 | 48           | 25.26 |
| 6. Clearing the rope: Jumping with both feet                                                     | 64         | 33.68 | 45              | 23.68 | 81           | 42.63 |
| 7. Clearing the rope: knees slightly bent using the ball of the feet                             | 93         | 48.95 | 79              | 41.58 | 18           | 9.47  |
| 8. Rope slides across the floor while clearing the rope                                          | 33         | 17.37 | 74              | 38.95 | 83           | 43.68 |

0 = No mastery; 1 = partial mastery; 2 = good mastery; n = number of subjects; %= mean percentage

Table 2 displays the percentages of quantitative mastering of rope skipping in the group. Low percentages of the group were able to successfully repeat the rope skipping action five times rhythmically when using both feet simultaneously. Only 36.32% (n= 69) of the group was successful in repeating the jumping pattern rhythmically five times using both feet in a rhythmic pattern, while clearing the rope successfully.

**Table 2 : Percentage quantitative mastering of the group in each sub-component**

| Quantitative criteria | N = 190 |       | N  |       | N       |       | N    |   |
|-----------------------|---------|-------|----|-------|---------|-------|------|---|
|                       | No      | %     | No | %     | Partial | %     | Good | % |
| 1. 5 x skipping       | 82      | 43.16 | 39 | 20.53 | 69      | 36.32 |      |   |
| 2. Skip with rhythm   | 116     | 61.05 | 8  | 4.21  | 66      | 34.74 |      |   |

The quantitative and qualitative mastering percentages of boys and girls are presented in Tables 3 and Table 4 and an analysis of the significance of sex differences are reported in Table 5. Girls outperformed the boys in each of the qualitative and quantitative aspects of the assessment as reported in tables 3 and 4. More than 50% of the girls showed good mastery of rope skipping five times using both feet and showing good rhythm (52%), compared to only 18.89% of the boys. The starting position and the grip on the rope were well mastered in both genders. Both boys and girls, displayed the lowest mastery in the jumping action with the knees slightly bent, executed from the ball of the foot. A 11.67% difference were also found, with boys showing the poorest mastery. Poor body posture while performing the skipping action and the forward swinging of the rope also showed poor mastery in both groups. Independent t-testing revealed significant execution differences in the qualitative and quantitative totals as well as the overall totals of boys and girls as presented in Table 5 ( $p < 0.05$ ). These differences between the groups were also of practical significance in all the totals, showing medium effects ( $d > 0.5$ ) where qualitative performance differences between boys and girls showed the largest practical significance ( $d = 0.77$ , table 5).

**Table 3: Percentage qualitative mastery in boys and girls**

| Qualitative criteria | Boys (N=90) |       |    |       |    |       | Girls (N=100) |      |    |       |    |       |
|----------------------|-------------|-------|----|-------|----|-------|---------------|------|----|-------|----|-------|
|                      | N           |       | %  |       | N  |       | N             |      | %  |       | N  |       |
|                      | 0           | 1     | 2  | 0     | 1  | 2     | 0             | 1    | 2  | 0     | 1  | 2     |
| 1. 5 x skipping      | 48          | 53.33 | 25 | 27.78 | 17 | 18.89 | 34            | 34.0 | 14 | 14.00 | 52 | 52.00 |
| 2. Skip with rhythm  | 70          | 77.78 | 5  | 5.56  | 15 | 16.67 | 46            | 46.0 | 3  | 3.00  | 51 | 51.00 |

0 = No mastery: Cannot execute the skill; 1 = partial mastering: Can execute this skill but not completely correct; 2 = good mastering: Can execute the skill well; n = number of subjects; and %= mean percentage

**Table 4: Percentage qualitative mastering of boys and girls in each sub-component**

|                              | n  | %     | n  | %       | n  | %     | N  | %     | N  | %       | N  | %     | Diff  |
|------------------------------|----|-------|----|---------|----|-------|----|-------|----|---------|----|-------|-------|
| Qualitative criteria         |    | No    |    | Partial |    | Good  |    | No    |    | Partial |    | Good  |       |
| 1. Starting position         | 3  | 3.33  | 38 | 42.22   | 49 | 54.44 | 8  | 8.00  | 21 | 21.00   | 71 | 71.00 | 16.56 |
| 2. Grip on rope              | 27 | 30.00 | 11 | 12.22   | 52 | 57.78 | 19 | 19.00 | 11 | 11.00   | 70 | 70.00 | 12.22 |
| 3. Back-upward rope swing    | 34 | 37.78 | 48 | 53.33   | 8  | 8.89  | 27 | 27.00 | 39 | 39.00   | 34 | 34.00 | 25.11 |
| 4. Head alignment with body  | 27 | 30.00 | 53 | 58.89   | 10 | 11.11 | 11 | 11.00 | 55 | 55.00   | 34 | 34.00 | 22.89 |
| 5. Forward-down rope swing   | 0  | 0.00  | 78 | 86.67   | 12 | 13.33 | 1  | 1.00  | 63 | 63.00   | 36 | 36.00 | 22.67 |
| 6. Jumping action both feet  | 41 | 45.56 | 26 | 28.89   | 23 | 25.56 | 23 | 23.00 | 19 | 19.00   | 58 | 58.00 | 32.44 |
| 7. Knees bending and landing | 55 | 61.11 | 32 | 35.56   | 3  | 3.33  | 38 | 38.00 | 47 | 47.00   | 15 | 15.00 | 11.67 |
| 8. Clearing the rope         | 19 | 21.11 | 45 | 50.00   | 26 | 28.89 | 14 | 14.00 | 29 | 29.00   | 57 | 57.00 | 28.11 |

0 = No mastery; 1 = partial mastering; 2 = good mastering; n = number of subjects; %= mean percentage; Diff=difference

**Table 5: Significance of qualitative and quantitative sex differences**

| Variables                             | Girls |       |      | Boys |      |      | Df  | T    | p     | d      |
|---------------------------------------|-------|-------|------|------|------|------|-----|------|-------|--------|
|                                       | N     | M     | SD   | N    | M    | SD   |     |      |       |        |
| Qualitative Total (16)                | 100   | 10.35 | 4.29 | 90   | 7.73 | 3.42 | 188 | 4.62 | 0.00* | 0.77** |
| Quantitative Total (4)                | 100   | 2.22  | 1.88 | 90   | 1.06 | 1.51 | 188 | 4.67 | 0.00* | 0.62** |
| Qualitative & Quantitative Total (20) | 100   | 12.57 | 6.02 | 90   | 8.79 | 4.71 | 188 | 4.79 | 0.00* | 0.63** |

M = mean; SD = standard deviation; df = degrees of freedom; N = number of subjects; p = p value ( $p < 0.05^*$ ); d = effect size ( $d \geq 0.2$  = small\*;  $d \geq 0.5$  = moderate\*;  $d \geq 0.8$  = large\*\*\*)

Table 6a and 6b displays the frequency distributions for the quantitative and qualitative scores that were obtained. These frequency distributions were used to develop an age appropriate assessment criterion with descriptors of mastery that can be used by teachers and other health practitioners to assess 6 and 7-year-olds, as displayed in Table 7. Table 6a displays the frequency distribution of the obtained scores in the quantitative assessment and reflects that a large number of the group ( $n=84$ ) failed to comply with the quantitative requirements, scoring a zero (0) (43.52%). Table 6b shows the point allocation based on the frequency distribution of the qualitative scores that were obtained in the group and the level of mastery that is associated with the quantitative total that are obtained by a child, divided into 4 quartiles. These descriptors can be used to describe the level of mastery in the 4 broad categories (poor, below, average, average and good). These broad descriptors were again refined in the rubric that was developed to be also aligned with the CAPS assessment descriptors (2011) of South African schools (Table 7) that include 7 descriptor levels. A descriptor of not achieved was also added in the rubric as part of the initial phase of development as there was one child that was not able to follow the demonstration and to perform the task at all.

**Table 6a: Frequency distribution of the quantitative criteria of mastery**

| Category | Number | Cumulative | Percentage | Cumulative |
|----------|--------|------------|------------|------------|
| Total 4  |        | Number     |            | Percentage |
| 0        | 84     | 84         | 43.52      | 43.52      |
| 1        | 32     | 116        | 16.58      | 60.10      |
| 2        | 4      | 120        | 2.073      | 62.18      |
| 3        | 3      | 123        | 1.55       | 63.73      |
| 4        | 67     | 190        | 34.72      | 98.45      |
| Missing  | 3      | 193        | 1.55       | 100.00     |

**Table 6b: Frequency distribution of the quantitative criteria and percentage mastery**

| Total 16   | N  | Cumulative n. | %     | Cumulative % | Percentile   | Mastery in group |
|------------|----|---------------|-------|--------------|--------------|------------------|
| 0          | 1  | 1             | 0.52  | 0.52         |              |                  |
| 1          | 1  | 2             | 0.52  | 1.04         |              |                  |
| 2          | 4  | 6             | 2.07  | 3.11         | 0-25%        | Poor             |
| 3          | 7  | 13            | 3.63  | 6.74         | 0-5 points   |                  |
| 4          | 12 | 25            | 6.22  | 12.95        |              |                  |
| 5          | 16 | 41            | 8.29  | 21.24        |              |                  |
| 6          | 14 | 55            | 7.25  | 28.49        | 25-50%       | Below average    |
| 7          | 29 | 84            | 15.03 | 43.52        | 6-7 points   |                  |
| 8          | 15 | 99            | 7.77  | 51.29        |              |                  |
| 9          | 9  | 108           | 4.66  | 55.96        |              |                  |
| 10         | 12 | 120           | 6.22  | 62.18        | 50-75%       | Average          |
| 11         | 4  | 124           | 2.07  | 64.25        | 8-12 points  |                  |
| 12         | 16 | 140           | 8.29  | 72.54        |              |                  |
| 13         | 9  | 149           | 4.66  | 77.20        |              |                  |
| 14         | 15 | 164           | 7.77  | 84.97        | 75-100%      | Good             |
| 15         | 14 | 178           | 7.25  | 92.23        | 13-16 points |                  |
| 16         | 12 | 190           | 6.22  | 98.45        |              |                  |
| Incomplete | 3  | 190           | 1.55  | 100.00       |              |                  |

n = number of subjects that received the score

Table 7 displays the assessment criteria rubric that was developed as a guideline to be used by practitioners in this field to assess mastery of rope jumping between the ages of 6 and 7 years. A mastery category descriptor is included in the rubric which is linked to the phase of development that it represents, and that is ascribed to that level. Six-year-olds who are still classified in the initial phase of development, and hence also mastery, will need much more experience or intervention to improve their rope skipping ability compared to one who are already classified in the mature or advanced skill level. Proficiency in a mature phase represents well-coordinated,

mechanically correct execution in a fluent manner which usually occurs around 6 to 7 years (Gallahue et al., 2012). Practitioners can only use the mastery descriptor or both descriptor categories to determine and described the level of development when reporting mastery or to make informed decisions on how to address it by means of development programs or intervention strategies for improvement.

**Table 7: Rubric of developmental characteristics and assessment criteria for rope skipping**

| Name:<br>Demonstrate 5 continuous two-legged rope jumps. The child then executes the skill. |                                                                                                                                                                         | Male /Female             |  | Phase of development |
|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--|----------------------|
|                                                                                             | Quantitative criteria                                                                                                                                                   | Assessment descriptors   |  | Quantitative I E M   |
| 1                                                                                           | Cannot execute rope skipping at all                                                                                                                                     | Not achieved             |  | (I)Initial phase     |
| 2                                                                                           | Skip 1-5 times one foot, other foot in a walking pattern                                                                                                                | Elementary performance   |  |                      |
| 3                                                                                           | Skip once with both feet but can't proceed/stop                                                                                                                         | Elementary performance   |  | (E)Elementary phase  |
| 4                                                                                           | Skip 1x using both feet, then change to a walking pattern, using one foot, other foot                                                                                   | Average performance      |  |                      |
| 5                                                                                           | Skip 2x using both feet, can't continue                                                                                                                                 | Satisfactory performance |  |                      |
| 6                                                                                           | Skip 3x using both feet, can't continue                                                                                                                                 | Substantial performance  |  |                      |
| 7                                                                                           | Skip 4x using both feet, can't continue                                                                                                                                 | Merit performance        |  | (M)Mature phase      |
| 8                                                                                           | Skip 5x using both feet and good rhythm                                                                                                                                 | Exceptional performance  |  |                      |
|                                                                                             | Qualitative criteria (technical execution) (0- no mastery = Initial phase [I]); (1=partially mastered=Elementary phase [E]); (2= Completely mastered, Mature phase [M]) |                          |  | 0-2 I E M            |
| 1                                                                                           | Starting position with rope behind the body at the ankles                                                                                                               |                          |  |                      |
| 2                                                                                           | Grip the rope with the palms facing forward and the thumbs slightly to the side at the start                                                                            |                          |  |                      |
| 3                                                                                           | Backward-upward swing of the rope behind the body                                                                                                                       |                          |  |                      |
| 4                                                                                           | Head aligned with a straight upper body, observe the rope at eye level when passing over the head                                                                       |                          |  |                      |
| 5                                                                                           | Forward and downswing of the rope in front of the body                                                                                                                  |                          |  |                      |
| 6                                                                                           | Start the jumping action to clear the rope with both feet simultaneously                                                                                                |                          |  |                      |
| 7                                                                                           | Jumping action with knees slightly bent using the balls of the feet                                                                                                     |                          |  |                      |
| 8                                                                                           | Rope slides across the floor while the jump is executed                                                                                                                 |                          |  |                      |

## Discussion

The results show that a large percentage of first graders did not yet master rope skipping at a level that they can skip rhythmically five times while using both feet during the take-off and landing phases of the jumping action. Only one-third of the group (32.73%) showed the ability to perform five rope skips consecutively (36.32%) and with good rhythm (34.74%). The results furthermore show that a large percentage of first graders also did *not* fully master the qualitative criteria of rope skipping as less than 50% complied with good mastery in most of the criteria. This inadequate competence in using the techniques of rope skipping might have contributed to the quantitative outcome that was found. Payne and Isaacs (2017) report in this regard that a significant association exists between the qualitative execution and the quantitative outcome of motor skills, therefore both should be assessed to fully understand mastery levels of motor skills. Not many studies exist to compare our results with. Researchers indicate that 5-year-old children have the ability to master rope skipping but don't provide any qualitative or quantitative guidelines to support such an opinion. In agreement to our results, Tse and co-workers (2017) reported only two successful repeated skips in Chinese children between 5 and 7-years of age, while the study of Pienaar et al. (2016) revealed that only 23.61% of 6.3-year-old children (N=72) from two different regions in South Africa were able to jump rope, five times. Rope skipping can therefore still be regarded as a complex skill for most first graders, or children in the age range between 6 and 7 years, to master completely, as many were still classified in the initial or elementary stages of reaching the benchmark proficiency level that was set to be achieved by them.

The swinging action of the rope at the back as well as in front of the body, as well as the body posture of the child during this part of the rope skipping action, showed low levels of mastering in up to 75% of the group. The video recordings that were analysed of each participant show that some children lean heavily to the front or to the back with the upper body during jumping, consequently influencing the position of the head and the level of the eyes to observe the rope when it moves over the head towards the front. This adapted posture is most probably the result of a poor swinging action of the rope. This poor posture again influences the balance of the body while skipping. Most of the children also did not land on the balls of the feet and presented with high knee lifting during the jumping phase where only 9.47% of the group showed good mastery of this criteria. The

level of efficiency of the process is also linked to the product efficiency, as shown in a study by Miller that deals with punching skills (2007). In agreement, we are also of the opinion that the ability to skip with good rhythm in a sequence depends largely on the mastering of the qualitative criteria of the rope skipping skill. The high lifting of the knees and landings on flat feet can most probably be ascribed towards this poor body posture, inadequate swinging of the rope that is usually the result of an arm action rather than a required wrist rotation action that disrupted the timing of the swinging action and the balance of the body. This resulted in the pulling up of the knees to clear the poorly timed and inadequate swinging of the rope that is most of time not swung near the floor and hence therefore difficult to clear with only a slight knee bending. This chain of events that go wrong during the sequence of rope skipping again interrupt the rhythm that is required to complete a sequence of rope jumping. Many children could not proceed with more than one rope skip most probably as a result of this poor execution techniques. The technique and body control that are required to perform a sequence of rope skips can therefore still be regarded as complex and not mastered well by most first graders, at least in South Africa, or children in the age group of 6 and 7 years, as many were still classified in the initial or elementary stages of reaching the benchmark proficiency level that was set to be achieved by them. Our results are in agreement with the findings of Tse et al. (2017) on 5 to 7-year-olds with a mean age of 5.84-years where the group obtained a 3 out of a possible 9 score for the process oriented assessment of the required criteria for rope skipping. The jumping action to clear the rope only with a slight knee lift and on the balls of the feet shows the poorest mastering of all the sub-components, and is probably the main reason why all the execution errors occur.

Clear sex differences were also found in the ability to perform well mastered rope skips that should be noted. *Girls* performed significantly better in all the mastering criteria of rope skipping (qualitative and quantitative) and the overall total than the boys ( $p < 0.05$ ;  $d > 0.5$ ). In the girls, 52% compared to 18.89 % of the boys could complete five rope skips, while 51% of girls and only 16.69 % of boys displayed good rhythm during the executing of rope skipping. The girls also scored 12.87 out of a possible 20 compared to a significantly lower total of 9.98 in the boys ( $p < 0.05$ ;  $d = 0.63$ ). This result is confirmed by the study of Pienaar on 6.3-year-old children from South Africa where 35.14% of the girls compared to 11.43% of the boys were able to repeat rope skipping, five times. Studies on slightly older Chinese children where rope skipping was used as part of fitness testing protocols, also confirm sex differences (Zhu et al. 2017; Ha et al. 2006). Two-legged jumping that is required in repetitive rope skipping is also reported to differ between boys and girls, where boys were found to be much less capable than the girls (Miller et al., 2007). Rope skipping is described by researchers as a playing activity of choice amongst young girls (Engelbrecht 2004; Micallef *et al.*, 2010; Resaland et al., 2019). This can contribute to more practice and experience of rope skipping through games, and can therefore result in superior skills development of rope skipping amongst girls, at least in older children. The question however, remains if this activity preference and hence the motor learning experiences that goes along with this, can also be attributed to the differences that were found in the earlier ages among boys and girls.

The assessment criteria that were used in this study should take these significant sex differences into account. These differences suggest that differential norms might be needed when assessing the mastering of rope skipping amongst boys and girls between 6 and 7-years-of-age. Our results suggest that most girls in grade 1 can be expected to rhythmically skip the rope five times in succession using both feet simultaneously, while three consecutive jumps can rather be expected from boys, based on their developmental level. More research is, however, recommended in this area. Exercises given to improve rope skipping skills in boys and girls, should also be aimed at the developmental shortcomings that were identified in this study, such as the large differences in the swinging action of the rope and the consecutive skipping ability of the boys relative to these abilities in the girls.

Rope skipping should be considered as a desirable form of general development in young children, but also as a health enhancing skill, therefore development of rope skipping abilities should be emphasised more strongly. It should also receive more attention in schools where children in grades 1-3 should be taught rope skipping as part of the Life Orientation learning area, as stated in the South African CAPS document (2011). First graders are at a stage where rope skipping can still be considered as a complex fundamental skill that needs further improvement with proper instruction. The challenges that were highlighted by this study in the complete mastering of rope skipping, as well as the process and product-oriented differences that were delineated between the boys and the girls should be addressed by teachers and other persons involved in the development of children. Rope skipping emerges more often in fitness protocols, therefore children should become proficient in rope skipping. Rope skipping also have remedial qualities and can also be used as a skill to identify shortcomings in the development of children because it requires overall coordination and bilateral integration from young children. In this regard it is shown that rope skipping has the ability to improve important skills such as bilateral integration, motor planning, hand-eye and foot-eye coordination (Cordoso & Magalhaes, 2009), which in turn contributes to better performance at school in basic skills such as writing and drawing.

The study had limitations that need to be highlighted. The conditions where rope skipping were assessed was not always optimal. The subjects were sometimes not dressed suitably because of cultural beliefs, the surface of the ground was sometimes uneven, and the results were based on cross-sectional data. In spite of this problems that was out of the control of the researchers, this study's strengths reside in the large and random sample that was used which increase the generalisation of the results. Although only a sub-region was used in



this randomly selected group of subjects, the results still have practical value that could be generalised to improve the understanding of the mastery of rope skipping in first graders in the North West Province of South Africa, while it can also be used as a guide of developmental expectations of rope skipping mastery, in doing similar research in other countries.

### Conclusions

Six to seven-year-old children still struggle to a great extent to meet the qualitative and quantitative requirements of rope skipping, as assessed in this study. Boys also find rope skipping at this age more difficult to master than girls, especially the qualitative aspects. An assessment rubric with mastery descriptors was developed by means of this study to assist health practitioners such as Physical Education teachers or trained Life Orientation teachers for screening purposes, to evaluate the skill of rope skipping. It can also be used to identify in which phase of development the child is regarding rope skipping, which again can assist in appropriate instructions to improve the skill. It can also be used to screen for motor problems amongst those who show very premature mastering of the skill at this age, which might be associated with bilateral integration and motor planning abilities that are required for rope skipping (see Table 7). Additionally, the assessment criteria can also be used for future research in this area. The qualitative part of the evaluation table specifically has value for specialists in Kinderkinetics who have to determine the nature of the problem while the quantitative part (thus the process evaluation) are typically of value to teachers because it was compiled according to the assessment guidelines in the CAPS document (2011). It is also strongly recommended that children in the age range between 5 and 8 years should be subjected to similar research in order to determine a complete age appropriate developmental profile of rope skipping. Further research aimed to determine the possible value of rope skipping in the identification of motor problems is also recommended.

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### Conflict of interest

There are no conflict of interest relating to any of the authors.

### Author contributions

AEP conceptualized and planned the study. Both authors listed (AEP and ABW) have worked together during data collection, and gave input into the writing, editing and final drafting of the paper.

### Authors summary

The research interest of Anita Pienaar focus on the longitudinal analysis of health, growth, physical activity and fitness in children and adolescents, affordances of motor development and motor proficiency in children and improvement of motor problems in children with differing special needs, aged 0-13 years. Andrea Brosdowski-Willis's research interests focus on the motor development of children from birth to 13 years of age. This study covers the development and assessment of a complex fundamental movement skill that has various benefits to children.

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