Reproducibility of motor competence tests and percentiles for children and adolescents living at moderate altitude in Peru

Marco Cossio-Bolaños, M.D.[a], *Rubén Vidal-Espinoza, Magister*[b], *Felipe Castelli Correia de Campos, M.D.*[c], *José Sulla-Torres, M.D.*[d], *Wilbert Cossio-Bolaños, M.D.*[e], *Camilo Urra-Albornoz, Magister*[f] *and Rossana Gómez-Campos, M.D.*[a]

ABSTRACT

Objective. To assess the reproducibility of two motor competence (MC) tests: moving sideways and jumping sideways, and to estimate age and sex percentiles for children living at moderate altitude in Peru.

Method. This was a descriptive, cross-sectional study conducted in the province of Arequipa, Peru. Weight, height, and waist circumference were assessed. Body mass index and ponderal index were estimated. The moving sideways and jumping sideways tests were assessed (both from the *Körper test für Kinder* test battery).

Results. The sample was made up of 885 girls and 897 boys aged 6.0-16.9 years. The intra-evaluator technical error of measurement for both MC tests ranged between 1.75 and 3.9 repetitions in both males and females, whereas the intraclass correlation coefficient was 0.77-0.99. Agreement limits ranged between -7.3 and 6.8 repetitions for both tests. The 5th, 15th, 50th, 85th, and 95th percentiles were estimated using the Least-Mean-Square algorithm. The cut-off points for MC tests were low: < p15; medium: p15-p85; and high: > p85.

Conclusion. Moving sideways and jumping sideways showed a high capacity for reproducibility. The proposed percentiles may be useful to assess MC and could be included and adapted as performance indicators in physical education.

Key words: *motor skills, reference standards, child, adolescent.*

http://dx.doi.org/10.5546/aap.2021.eng.91

To cite: Cossio-Bolaños M, Vidal-Espinoza R, Castelli Correia de Campos F, Sulla-Torres J, et al. Reproducibility of motor competence tests and percentiles for children and adolescents living at moderate altitude in Peru. *Arch Argent Pediatr* 2021;119(2):91-98.

a. Universidad Católica del Maule, Talca, Chile.
b. Universidad Católica Silva Henríquez, Santiago, Chile.
c. Universidad del Bio-Bio, Chillán, Chile.
d. Universidad Nacional de San Agustín de Arequipa, Arequipa, Perú.
e. Universidad Privada San Juan Bautista, Lima, Perú.
f. School of Kinesiology, School of Health, Universidad Santo Tomás, Chile.

E-mail address:
Rossana Gómez Campos, M.D: rossaunicamp@gmail.com.

Funding:
None.

Conflict of interest:
None.

Received: 5-22-2020
Accepted: 10-26-2020

INTRODUCTION

The development of motor competence (MC) is one of the bases of human motor behavior: it works, as a direct and indirect building block for a number of activities throughout life.[1] MC is essential for many daily functional tasks, including work, sports, recreational activities,[2] among others. MC is defined as the ability to proficiently perform different motor actions, including fine and gross motor skills,[3] and movement patterns.[4] In general, the development of MC does not occur naturally; it requires practice and experience to successfully express it in different activities requiring its inherent implementation.[5]

Actually, physical education (PE) plays a key role in the development of motor skills and, subsequently, in MC.[6] Education curricular programs include different dimensions of MC (basic skills, coordination, balance, stability, etc.), which allow children and adolescents to successfully take part in PE classes (games, sports, dancing, recreational activities, etc.) given that their performance requires certain level of MC.

In this setting, several studies have demonstrated that MC is related to physical activity, physical fitness, and body weight patterns.[7,10] Such evidence supports the interest to include it in PE assessments, because high MC levels will generally have an impact on physical activity (PA) programs and on the promotion of positive health trajectories throughout life.[1]

The current bibliography describes quantitative and qualitative tests to

assess MC. However, many quantitative tests are difficult to implement and tiresome and require sophisticated materials and specific training, given that many of them have been developed for clinical and medical purposes; in general, they are used to identify children with motor disabilities.[11] This hinders the possibility of a rapid assessment and integration of motor outcome measures that are routinely measured during PE classes.

Under these premises, this study sought to find a method that better adapted to PE assessments. Therefore, two of the four tests proposed in the *Körperkoordinationstest Für Kinder* (*KTK*) test battery[12] were selected. Both moving sideways (MS) and jumping sideways (JS) assess MC. These are apparently the simplest and most easily implemented tests, so their use to assess PE may be a relevant option.

As a consequence, this study proposes that both tests may have a high capacity for reproducibility and, at the same time, the use of percentiles may serve as an indicator of performance for the assessment of MC among children and adolescents. Therefore, the objectives of this study were to assess the capacity for reproducibility of the MS and JS motor tests and to estimate age and sex percentiles for children and adolescents living at moderate altitude in Peru.

METHODS

Sample and type of study

This was a cross-sectional study conducted in children and adolescents in the city of Arequipa, located in the south of Peru at 2320 meters above sea level. Participants were primary and secondary school students from public schools in the urban area. Arequipa had approximately 30 reference schools distributed into two areas: south and north. Two schools were randomly selected per area. These accounted for 17 200 students (population). The sample was selected in a probabilistic (stratified) fashion and corresponded to 10.3 % (95 % confidence interval [CI]).

Inclusion and exclusion criteria

The study included children and adolescents whose parents and/or legal guardians signed the informed consent and who attended school on the assessment day. Parents and legal guardians had been informed, in advance, of the procedure to assess their children's MC. Children and adolescents with a physical disability that prevented them from performing motor tests and those who did not complete two assessments were excluded.

The board of each school authorized the study conduct. The study was carried out in accordance with the Declaration of Helsinki for human subjects and the recommendations of the local Ethics Committee (UNSA-2017-15).

Procedures and techniques

Anthropometric measurements and MC tests were carried out in the school facilities during school hours (8:00 am-12:30 pm) Mondays through Fridays between April and July 2017. Anthropometric measurements were done first, followed by MC tests.

Anthropometric measurements were assessed in accordance with Ross & Marfell-Jones' recommendations.[13] Body weight (kg) was measured using an electronic scale (Tanita, United Kingdom) with a 100 g precision and a range from 0 to 150 kg. Standing height was measured using a portable stadiometer (Seca Gmbh & Co. KG, Hamburg, Germany), with a 0.1 mm precision. Waist circumference (WC) was measured using a Seca metal tape measure graduated in millimeters with a 0.1 cm precision. The following formulas were used to estimate body mass index (BMI): BMI = weight (kg)/ height^2 (m), and the ponderal index (PI): PI = weight (kg)/height^3 (m).

MC tests (MS and JS) were assessed upon a 10-minute warm-up. An investigator performed all assessments, supported by two assistants. Assessments were carried twice by the same evaluator seven days apart (intra-evaluator).

Both MC tests were part of the *KTK* test battery,[12] which included MC components, such as balance, rhythm, strength, laterality, speed, and agility.[14] The MS test allowed to assess participants' laterality and space-time structure. The child stood on a wooden platform (25 cm x 25 cm x 1.5 cm, with 4 legs 3.7 cm high) while holding a second platform in their hands, facing the floor. At the start signal, the child had to place the second platform next to the one where they were standing on and move on to it; the sequence continued over 20 seconds. The number of relocations was recorded (as repetitions).

The JS test consisted in jumping on both feet as fast as possible from side to side over a small beam (60 cm, 4.0 cm x 2.0 cm) over 15 seconds. The number of jumps was recorded (as repetitions). Time was controlled using a Casio stopwatch (HS-70W-8EF).

Results were reported to parents. Extreme cases of low motor performance and high body weight levels were referred to specialists for potential treatment.

Statistics

Data normality was verified using the Kolmogorov-Smirnov (KS) goodness-of-fit test. Descriptive statistics (average, standard deviation, and percentage) were estimated. The comparison between sexes was obtained using the t test for independent samples. The three categories of the motor tests were compared using an analysis of variance (ANOVA) and Tukey's specificity test. The absolute technical error of measurement (TEM) for test and re-test (TEM = $\sqrt{\sum d2/2n}$) was estimated as suggested by Norton and Olds.[15] For an easier interpretation of absolute TEM values, the relative TEM (%TEM) was estimated as (TEM/Mv) x 100, where Mv was the overall mean between the test and re-test. %TEM values below 5 % were considered acceptable.[16] The intraclass correlation coefficient (ICC) and Bland-Altman plots[17] were also used to assess the agreement between the test and re-test for JS and MS. Estimations were done using the SPSS 18.0 software. A p value < 0.05 was considered as significant.

Age and sex percentiles were developed for the MS and JS tests. The Least-Mean-Square algorithm (LMS) was applied.[18] The L, M, and S curves accounted for asymmetry (lambda), median (mu), and coefficient of variation (sigma). The L, M, and S parameters were estimated based on the maximum penalty.[19] The following percentiles were calculated: p5, p15, p50, p85, and p95. Data were processed using the LMS Chartmaker software (The Institute of Child Health, London, United Kingdom).[20]

RESULTS

A total of 1882 school children and adolescents (885 boys and 897 girls) were assessed. The characteristics of the studied sample and normality values for the outcome measures by age and sex are shown in *Table 1*. Anthropometric and motor outcome measures showed a normal distribution in both males and females and across

Table 1. *Anthropometric, motor, and education characteristics of the study sample by sex*

	N	Weight			Height (cm)			WC (cm)			Moving sideways (repetitions)			Jumping sideways (repetitions)			BMI (kg/m²)			PI (kg/m³)		
		X	SD	K-S	X	SD	K-S	X	SD	K-S	X	SD	K-S	X	SD	K-S	X	SD	K-S	X	SD	K-S
Boys																						
6	56	25.5	6.0	0.189	124.8	5.2	0.116	63.5	8.6	0.168	18.6	4.1	0.120	29.3	9.4	0.099	16.3	2.9	0.163	12.8	2.1	0.171
7	77	31.8	8.5	0.169	134.9	8.7	0.163	67.6	10.2	0.135	21.6	4.7	0.109	33.3	12.5	0.129	17.3	3.3	0.118	12.9	2.3	0.168
8	70	35.4	10.0	0.130	136.9	5.8	0.123	71.5	12.8	0.099	22.3	4.6	0.139	33.3	11.1	0.086	18.9	4.1	0.116	13.0	2.7	0.105
9	80	40.1	9.9	0.110	146.0	8.1	0.056	71.8	11.8	0.096	22.0	5.0	0.155	37.8	10.0	0.150	19.4	3.7	0.128	13.0	2.5	0.077
10	61	42.6	14.8	0.150	146.2	9.1	0.132	72.1	11.7	0.075	22.8	5.6	0.126	37.6	9.9	0.122	19.6	4.7	0.126	13.0	2.9	0.148
11	85	43.5	8.9	0.094	147.1	7.6	0.075	74.0	9.1	0.124	18.0	6.3	0.196	36.3	11.3	0.113	19.8	3.5	0.067	13.1	2.4	0.068
12	86	46.3	10.9	0.086	152.2	7.2	0.059	74.2	9.8	0.120	15.2	5.4	0.212	35.7	11.7	0.146	20.2	3.7	0.112	13.1	2.2	0.129
13	92	51.7	11.2	0.105	158.2	6.9	0.086	75.8	10.9	0.093	15.0	7.8	0.207	35.1	12.6	0.099	20.6	3.8	0.087	13.4	2.4	0.092
14	95	58.4	12.1	0.095	164.3	7.0	0.064	77.1	8.6	0.113	15.2	6.7	0.237	37.3	13.5	0.102	21.4	3.6	0.115	13.4	2.1	0.099
15	89	59.0	9.0	0.071	165.9	5.5	0.058	78.3	7.7	0.090	14.8	7.5	0.222	37.9	15.1	0.106	21.5	2.8	0.083	13.8	1.7	0.089
16	94	62.4	12.1	0.118	166.9	6.2	0.082	80.2	10.4	0.114	14.8	6.7	0.163	40.0	15.5	0.112	22.4	4.0	0.139	13.9	2.4	0.133
Girls																						
6	57	23.6	4.9	0.157	120.9	5.4	0.114	58.8*	8.8	0.114	18.2	4.5	0.140	30.5	10.0	0.128	15.6	3.0	0.170	12.6	2.5	0.172
7	81	32.5	9.1	0.125	134.8	7.8	0.064	66.0	9.6	0.086	21.5	3.3	0.091	33.5	10.4	0.173	17.6	3.5	0.118	12.7	2.3	0.097
8	80	35.0	9.0	0.086	139.9	8.2	0.086	67.9*	18.8	0.203	22.7	5.3	0.162	35.0	12.3	0.067	17.7	3.6	0.095	13.0	2.4	0.089
9	85	37.7	9.3	0.133	143.9	8.1	0.107	68.2*	9.7	0.108	22.7	4.5	0.118	40.1	11.0	0.142	18.1	3.5	0.120	13.0	2.3	0.120
10	74	41.8	9.1	0.091	146.8	7.1	0.119	70.2	12.0	0.088	22.9	7.3	0.113	41.3	13.2	0.135	19.2	3.4	0.123	13.1	2.3	0.128
11	82	42.9	9.1	0.122	147.2	6.5	0.065	71.5*	8.9	0.092	17.5	6.9	0.205	35.0	14.2	0.127	19.8	3.4	0.098	13.4	2.3	0.084
12	91	48.9	11.8	0.129	151.6	6.4	0.109	72.2	8.6	0.065	13.7	6.6	0.279	31.3*	14.3	0.207	21.2	4.4	0.109	13.7	2.8	0.131
13	82	51.4*	9.6	0.105	154.4*	5.2	0.077	73.3	7.4	0.099	13.5	5.3	0.178	33.5*	12.6	0.141	21.5	3.6	0.071	13.9	2.3	0.081
14	83	53.1*	9.8	0.115	156.3*	5.8	0.121	74.5*	7.8	0.072	14.7	9.0	0.242	29.2*	12.9	0.139	21.5	3.7	0.098	14.0	2.4	0.077
15	82	54.0*	8.3	0.108	157.0*	5.5	0.068	75.1*	6.9	0.074	14.4	6.3	0.211	30.1*	11.5	0.088	22.1	3.1	0.097	14.1	2.1	0.115
16	100	55.5*	8.0	0.111	158.2*	4.6	0.138	75.4*	7.9	0.085	14.8	7.4	0.189	29.1*	14.0	0.075	22.2	3.1	0.072	14.1	2.1	0.061

X: average; SD: standard deviation; MC: motor competence; BMI: body mass index; PI: ponderal index;
WC: waist circumference (*: significant difference in relation to boys, p < 0.05); K-S: Kolmogorov-Smirnov.

all age groups. In relation to body weight and height, girls had lower values from 13 to 16 years compared to boys ($p < 0.05$); across the other age groups, there were no significant differences. In relation to WC, boys showed higher values than girls at 6, 8, 9, 11, 14, 15, and 16 years ($p < 0.05$), whereas no differences were observed at 7, 10, 12, and 13 years ($p > 0.05$). No significant differences were observed between males and females in terms of BMI, PI, and MS ($p > 0.05$). In relation to the JS test, boys had higher values from 12 to 16 years compared to girls ($p < 0.05$). No significant differences were observed in the initial age groups, from 6 to 11 years ($p > 0.05$).

Reproducibility values described as %TEM are shown in *Table 2*. In the MS test, the %TEM ranged between 1.75 % and 3.38 % among boys and between 1.85 % and 3.64 % among girls. The correlations ranged between 0.77 and 0.98, respectively. In the JS test, the %TEM for boys ranged between 2.94 % and 3.97 % and for girls, between 2.90 % and 3.99 %. The ICC for boys ranged between 0.88 and 0.98, whereas for girls it was slightly higher (between 0.91 and 0.99).

In addition, the agreement established using the Bland-Altman plot (see *Figure 1*) showed that the difference in averages between the test and re-test for MS among boys was 1.02 ± 2.39 repetitions, and limits ranged between -5.7 and 3.7 repetitions. In the case of girls, the difference in averages was 0.78 ± 2.54 repetitions, and limits ranged between -5.8 and 4.2 repetitions. For the JS test, boys showed an average of 0.34 ± 3.57 repetitions, with a range between -7.3 and 6.7 repetitions. However, girls showed a difference in averages that was slightly higher (0.48 ± 3.54 repetitions), with limits that ranged between -5.8 and 4.2 repetitions. In all cases, values were acceptable.

The percentile distribution (p5, p15, p50, p85, p95) for both tests based on age and sex is shown in *Table 3*. The percentile distribution for both MC tests (MS and JS) by age and sex is observed in *Figure 2*.

The comparisons of body fat indicators (BMI, PI, and WC) based on MC categories are shown in *Table 4*. The MS showed significant differences between the three categories (low, medium, and high), both in relation to BMI and PI ($p < 0.05$), whereas no differences were observed in WC between the medium and high categories; this was not the case of the low category ($p < 0.05$).

No differences between the medium and high categories were observed in the JS test in terms of BMI, PI, and WC ($p > 0.059$). However, these two categories showed significant differences with those classified as low in the three body fat indicators ($p < 0.05$).

DISCUSSION

Results have evidenced adequate reproducibility values, as expressed by the TEM and the ICC. These findings are similar to those of the original study in German children for the raw score[12] and in Portuguese children with the same tests.[21] Even for both tests; the %TEM of this study was lower than 3.9 % and showed a high level of agreement between both assessments.

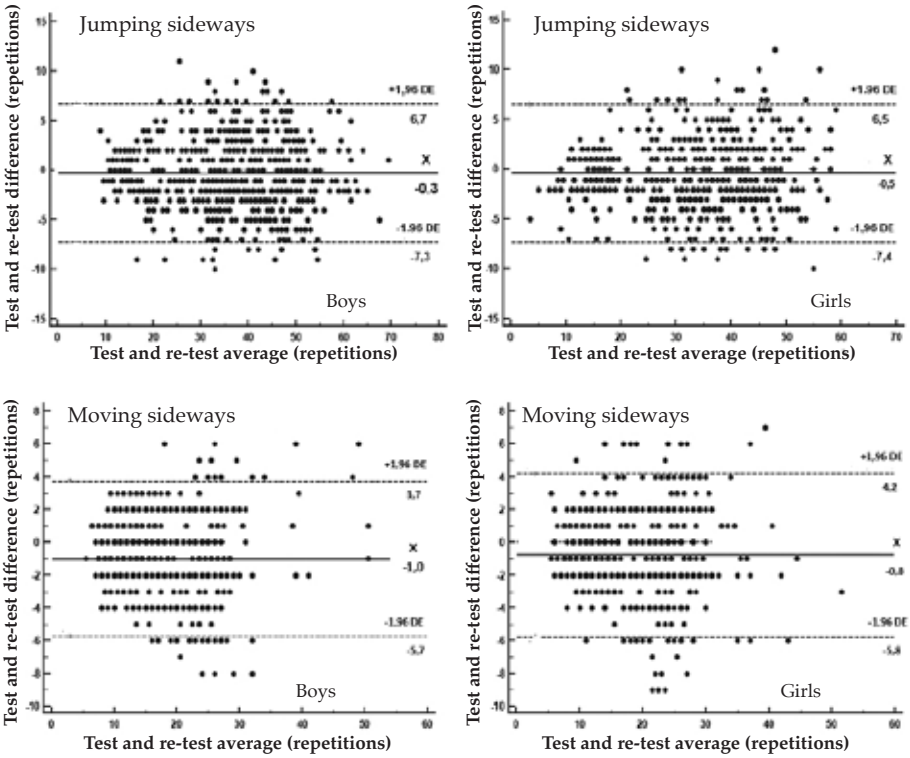
Test and re-test reproducibility with a 7-day interval provided reliable estimations for both

TABLE 2. *Test and re-test reproducibility values, described as technical error of measurement (%) and motor competence test correlation by age and sex*

Age (años)	Moving sideways (repetitions)						Jumping sideways (repetitions)					
	Boys			Girls			Boys			Girls		
	TEM (%)	ICC	*p*	TEM (%)	ICC	*p*	TEM (%)	ICC	*p*	TEM (%)	ICC	*p*
6.0-6.9	2.16	0.90	0.0036	2.92	0.85	0.0047	3.57	0.90	0.0037	3.99	0.92	0.0035
7.0-7.9	3.38	0.77	0.0054	2.74	0.80	0.0046	3.92	0.95	0.0014	3.57	0.95	0.0014
8.0-8.9	3.17	0.80	0.0051	3.27	0.83	0.0039	3.90	0.94	0.0020	3.96	0.96	0.0013
9.0-9.9	2.91	0.87	0.0030	3.28	0.77	0.0049	3.97	0.88	0.0045	3.68	0.91	0.0030
10.0-10.9	2.90	0.90	0.0035	3.64	0.87	0.0036	3.80	0.93	0.0027	3.98	0.97	0.0010
11.0-11.9	2.75	0.93	0.0016	3.13	0.94	0.0014	3.84	0.94	0.0016	3.84	0.96	0.0010
12.0-12.9	2.12	0.95	0.0013	2.05	0.95	0.0010	3.27	0.97	0.0012	3.05	0.99	0.0004
13.0-13.9	1.75	0.98	0.0005	1.85	0.94	0.0017	3.06	0.98	0.0006	3.27	0.96	0.0013
14.0-14.9	2.14	0.96	0.0009	1.90	0.98	0.0006	3.62	0.97	0.0008	3.80	0.98	0.0009
15.0-15.9	2.12	0.96	0.0010	2.02	0.98	0.0007	2.95	0.98	0.0005	2.90	0.97	0.0008
16.0-16.9	2.53	0.96	0.0012	2.02	0.97	0.0008	2.94	0.98	0.0004	3.83	0.94	0.0047
Total	2.60	0.94	0.0001	2.66	0.94	0.0001	3.58	0.96	0.0001	3.59	0.962	0.0001

TEM (%): relative technical error of measurement; r: Pearson; p: significance; ICC: intraclass correlation coefficient.

FIGURE 1. *Agreement between test and re-test values of motor competence tests using a Bland-Altman plot for both males and females*



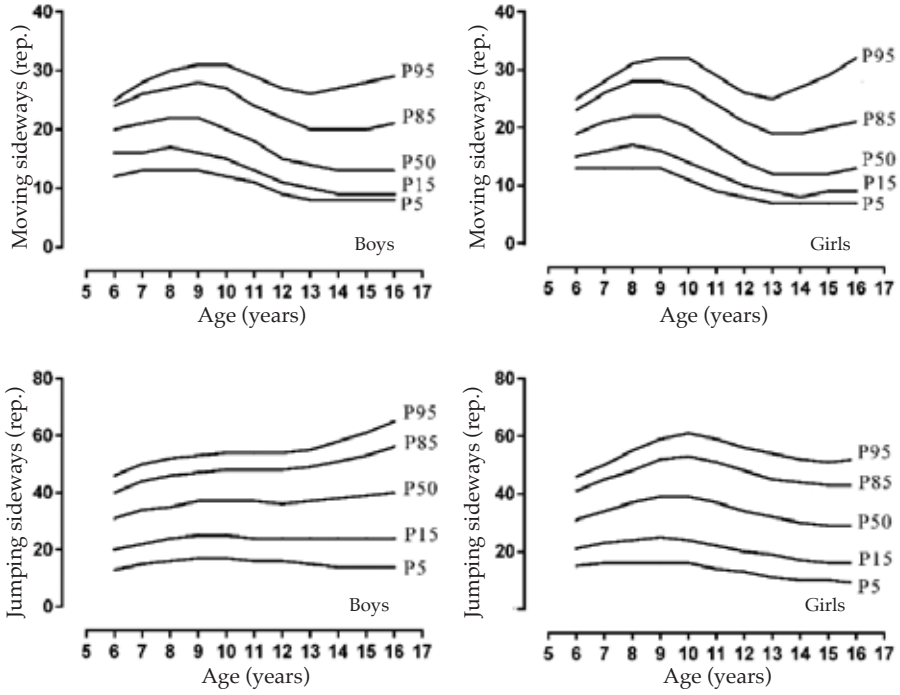
The dotted line (---) indicates the 95% limits of agreement as determined by the average difference (test and re-test) ± 1.96 times the standard deviation of the differences; Y = 0 indicates the optimal agreement line.

TABLE 3. *Percentiles for the moving sideways and jumping sideways tests among children by age and sex*

Age	Moving sideways (repetitions)								Jumping sideways (repetitions)							
(years)	L	M	S	P5	P15	P50	P85	P95	L	M	S	P5	P15	P50	P85	P95
Boys																
6.0-6.9	1.86	19.84	0.19	12	16	20	24	25	1.29	30.71	0.32	13	20	31	40	46
7.0-7.9	1.52	21.35	0.21	13	16	21	26	28	1.32	33.56	0.31	15	22	34	44	50
8.0-8.9	1.18	22.03	0.23	13	17	22	27	30	1.34	35.44	0.30	16	24	35	46	52
9.0-9.9	0.81	21.65	0.26	13	16	22	28	31	1.35	36.60	0.30	17	25	37	47	53
10.0-10.9	0.43	20.09	0.28	12	15	20	27	31	1.36	36.90	0.30	17	25	37	48	54
11.0-11.9	0.08	17.53	0.31	11	13	18	24	29	1.34	36.63	0.30	16	24	37	48	54
12.0-12.9	-0.22	15.07	0.33	9	11	15	22	27	1.30	36.34	0.31	16	24	36	48	54
13.0-13.9	-0.41	13.57	0.35	8	10	14	20	26	1.25	36.60	0.33	15	24	37	49	55
14.0-14.9	-0.51	13.09	0.37	8	9	13	20	27	1.20	37.56	0.35	14	24	38	51	58
15.0-15.9	-0.54	13.02	0.38	8	9	13	20	28	1.17	38.86	0.36	14	24	39	53	61
16.0-16.9	-0.54	13.16	0.39	8	9	13	21	29	1.14	40.31	0.38	14	24	40	56	65
Girls																
6.0-6.9	1.53	19.42	0.19	13	15	19	23	25	1.22	31.30	0.29	15	21	31	41	46
7.0-7.9	1.26	21.07	0.21	13	16	21	26	28	1.21	34.01	0.31	16	23	34	45	50
8.0-8.9	0.98	22.07	0.24	13	17	22	28	31	1.18	36.67	0.32	16	24	37	48	55
9.0-9.9	0.69	21.75	0.28	13	16	22	28	32	1.14	38.62	0.33	16	25	39	52	59
10.0-10.9	0.38	19.87	0.31	11	14	20	27	32	1.09	38.64	0.35	16	24	39	53	61
11.0-11.9	0.07	16.75	0.34	9	12	17	24	29	1.02	36.50	0.37	14	22	37	51	59
12.0-12.9	-0.20	13.86	0.36	8	10	14	21	26	0.95	33.79	0.39	13	20	34	48	56
13.0-13.9	-0.40	12.33	0.38	7	9	12	19	25	0.88	31.62	0.41	11	19	32	45	54
14.0-14.9	-0.54	11.96	0.39	7	8	12	19	27	0.84	29.97	0.43	10	17	30	44	52
15.0-15.9	-0.64	12.33	0.40	7	9	12	20	29	0.83	29.08	0.44	10	16	29	43	51
16.0-16.9	-0.71	12.79	0.41	7	9	13	21	32	0.84	28.67	0.46	9	16	29	43	52

P: percentile; M: median; S: coefficient of variation; L: Box-Cox power transformation.

FIGURE 2. *Selected percentiles of motor competence test scores for children in Arequipa, Peru, by age and sex*



Rep.: repetitions.

TABLE 4. *Average ± standard deviation values of body fat indicators, classified into low, normal, and high level of motor competence for both males and females*

Tests/categories	n	BMI (kg/m²)		PI (kg/m³)		WC (cm)	
		X	SD	X	SD	X	SD
Moving sideways							
Boys							
Low (< p15)	143	21.3	4.5	14	2.7	76.6	12.2
Medium (p15-p85)	612	19.9	3.9[a]	13.2	2.3[a]	73.7	10.3[a]
High (> p85)	130	18.9	3.3[ab]	12.6	1.9[ab]	72.3	9.4[a]
Total	885	20	4.0	13.2	2.3	74.0	10.5
Girls							
Low (< p15)	139	21.3	4.3	14.5	2.6	73.5	10.9
Medium (p15-p85)	628	19.9	4.1[a]	13.4	2.4[a]	70.8	10.8[a]
High (> p85)	130	18.3	3.0[ab]	12.4	1.8[ab]	69.1	8.2[a]
Total	897	19.9	4.0	13.5	2.4	71.0	10.5
Jumping sideways							
Boys							
Low (< p15)	172	21.8	4.7	14.2	2.8	78.0	12.5
Medium (p15-p85)	565	19.6	3.7[a]	13	2.2[a]	73.2	10.1[a]
High (> p85)	148	19.1	3.6[a]	12.7	2.1[a]	71.7	8.9[a]
Total	885	20.0	4.0	13.2	2.4	73.9	10.6
Girls							
Low (< p15)	195	22.0	4.9	14.9	3.0	75.7	13.8
Medium (p15-p85)	562	19.1	3.6[a]	13.0	2.0[a]	69.6	9.1[a]
High (> p85)	140	19.7	3.4[a]	13.3	2.0[a]	69.5	9.6[a]
Total	897	19.8	4.0	13.5	2.4	70.9	10.6

X: average; SD: standard deviation; BMI: body mass index; PI: ponderal index; WC: waist circumference;
a: significant difference ($p < 0.05$) in relation to the low category;
b: significant difference ($p < 0.05$) in relation to the medium category.

motor tests. Such interval of time between both assessments has been widely recommended in the literature[22] to warrant an adequate result interpretation.[23]

Basically, both the MS and the JS tests are highly reliable for routine use in the school education system because they have evidenced reasonable agreement limits. Their implementation and use during growth and development[24] may be relevant, because other MC assessment protocols generally include complex criteria, often require sophisticated instruments, and measurement is time-consuming.

Therefore, based on our results, it is believed that the age and sex percentiles estimated for the MS and JS tests may be used in a generalized manner in school children and adolescents whose characteristics are similar to those in this study. This information is necessary for an adequate assessment of obtained values; the scores obtained in one schoolchild may be compared to those of the general population to establish their relative position.

The proposed percentiles may help to establish performance thresholds between children and adolescents identifying MC levels as low, medium, and high. These cut-off points are based on the original study proposed by Kiphard, Schilling[25] (< p15, p15-p85, and > p85).

Actually, after comparing the mentioned categories, results indicate that children classified as having a poor MC had a higher BMI, PI, and WC than their peers with a better or higher MC level. These findings are consistent with those of other studies.[2,9]

Therefore, a low MC level and/or poor motor skills in children may be the result of multiple factors, such as not having received adequate motor skill training and/or not practicing them enough.[26] In addition, a lack of interest and the conditions of the setting where they grow may limit their performance. As a result, this may have adverse effects on daily life activities, including leisure and sports,[27] and reflect a low level of motivation to take part in physical activity programs.[28]

On the contrary, children with a better motor coordination tend to have a better physical fitness and be more active[29-31] because such behavior has an impact on their ability to participate in physical activity programs and encourages a positive health promotion for life.[1] The gap in performance levels among children may be even higher because those with a better performance may apparently achieve a better MC level and take part in more demanding physical activities,[32] although such aspects may depend on motivation and the sociocultural setting where children and adolescents live.

As a consequence, the percentiles proposed in this study may be used in health, sports, and PE programs in Arequipa (Peru) since they provide relevant information to identify subjects with varied motor performance levels and even help with sport talent scouting.[33]

This study poses certain limitations because it was not possible to assess physical activity and physical fitness patterns which would have provided relevant information for result analysis. In addition, only the intra-evaluator TEM was assessed, so findings should be analyzed with caution.

Notwithstanding the preceding, it is worth noting that this study is one of the first ones with such a large sample and broad age range. It may be used as the baseline for future comparisons. In addition, estimations may be done in the following link: http:// www.reidebihu.net/comp_mot-pe.php.

To conclude, the MS and JS tests demonstrated a high capacity for reproducibility and the proposed percentiles may allow to group children and adolescents based on their motor performance profiles and to adapt and use them in PE programs. ■

REFERENCES

1. Hulteen RM, Morgan PJ, Barnett LM, Stodden DF, et al. Development of foundational movement skills: A conceptual model for physical activity across the lifespan. *Sports Med*. 2018; 48(7):1533-40.
2. Lima RA, Bugge A, Ersbøll AK, Stodden DF, et al. The longitudinal relationship between motor competence and measures of fatness and fitness from childhood into adolescence. *J Pediatr (Rio J)*. 2019; 95(4):482-8.
3. Henderson SE, Sugden D, Psychological Corporation. Movement assessment battery for children. Sidcup: Psychological Corp; 1992.
4. Hands B, Rose E, Chivers P, McIntyre F, et al. The relationships between motor competence, physical activity, fitness and self-concept in children and adolescents with DCD. *Curr Dev Disord Rep*. 2020; 7:35-42.
5. Stodden DF, Goodway JD, Langendorfer SJ, Roberton MA, et al. A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest*. 2008; 60(2):290-306.
6. Cardon GM, De Bourdeaudhuij IMM. Physical education and physical activity in elementary schools in Flanders. *Eur J Phys Educ*. 2002; 7:5□18.
7. Hands B, Larkin D, Parker H, Straker L, et al. The relationship among physical activity, motor competence and health□related fitness in 14□year□old adolescents. *Scand J Med Sci Sports*. 2009; 19(5):655-63.

8. Stodden D, Langendorfer S, Roberton MA. The association between motor skill competence and physical fitness in young adults. *Res Q Exerc Sport*. 2009; 80(2):223-9.
9. Lopes VP, Stodden DF, Bianchi MM, Maia JA, et al. Correlation between BMI and motor coordination in children. *J Sci Med Sport*. 2012; 15(1):38-43.
10. Stodden DF, Gao Z, Goodway JD, Langendorfer SJ. Dynamic relationships between motor skill competence and health-related fitness in youth. *Pediatr Exerc Sci*. 2014; 26(3):231-41.
11. Tidén A, Lundqvist C, Nyberg M. Development and initial validation of the NyTid test: A movement assessment tool for compulsory school pupils. *Meas Phys Educ Exerc Sci*. 2015; 19(1):34-43.
12. Kiphard EJ, Schilling F. Korper-koordinations-test fur kinder. Ktk. Weiheim: Beltz Test GmbH; 1974.
13. Ross WD, Marfell-Jones MJ. Kinanthropometry. In: MacDougall JD, Wenger HA, Geen HJ (eds.). *Physiological testing of elite athlete*. London: Human Kinetics. 1991; 223:308-14.
14. Scordella A, Di Sano S, Aureli T, Cerratti P, et al. The role of general dynamic coordination in the handwriting skills of children. *Front Psychol*. 2015; 6:580.
15. Norton K, Olds T (eds.). Anthropometrica: a textbook of body measurement for sports and health courses. Sydney: UNSW press; 1996.
16. Lohman TG. Dual energy X-ray absorptiometry. In: Roche AF, Heymsfield SB, Lohman TG (eds.). *Human Body Composition*. Champaign, IL: Human Kinetics; 1996. Pages 63-78.
17. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*. 1986; 1(8476):307-10.
18. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ*. 2000; 320(7244):1240-3.
19. Cole TJ, Green PJ. Smoothing reference centile curves: the LMS method and penalized likelihood. *Stat Med*. 1992; 11(10):1305-19.
20. Pan H, Cole TJ. LMS Chartmaker. 2006. [Accessed on: March 28th, 2015]. Available at: http://www.healthforallchildren.co.uk.
21. Antunes AM, Maia JA, Stasinopoulos MD, Gouveia ÉR, et al. Gross motor coordination and weight status of Portuguese children aged 6□14 years. *Am J Hum Biol*. 2015; 27(5):681-9.
22. Lander N, Morgan PJ, Salmon J, Logan SW, et al. The reliability and validity of an authentic motor skill assessment tool for early adolescent girls in an Australian school setting. *J Sci Med Sport*. 2017; 20(6):590□4.
23. Palisano R, Rosenbaum P, Walter S, Russell D, et al. Development and reliability of a system to classify gross motor function in children with cerebral palsy. *Dev Med Child Neurol*. 1997; 39(4):214-23.
24. Hardy LL, Barnett L, Espinel P, Okely AD. Thirteen-year trends in child and adolescent fundamental movement skills: 1997-2010. *Med Sci Sports Exerc*. 2013; 45(10):1965-70.
25. Kiphard EJ, Schilling F. Körperkoordinationstest für kinder: KTK. Weinheim; Beltz-Test; 2007.
26. Goodway JD, Branta CF. Influence of a motor skill intervention on fundamental motor skill development of disadvantaged preschool children. *Res Q Exerc Sport*. 2003; 74(1):36-46.
27. Summers J, Larkin D, Dewey D. Activities of daily living in children with developmental coordination disorder: dressing, personal hygiene, and eating skills. *Hum Mov Sci*. 2008; 27(2):215-29.
28. Haga M. Physical fitness in children with high motor competence is different from that in children with low motor competence. *Phys Ther*. 2009; 89(10):1089-97.
29. Fransen J, Pion J, Vandendriessche J, Vandorpe B, et al. Differences in physical fitness and gross motor coordination in boys aged 6–12 years specializing in one versus sampling more than one sport. *J Sports Sci*. 2012; 30(4):379-86.
30. Cattuzzo MT, Henrique RDS, Ré AHN, De Oliveira IS, et al. Motor competence and health related physical fitness in youth: a systematic review. *J Sci Med Sport*. 2016; 19(2):123-9.
31. Jaakkola T, Yli□Piipari S, Huotari P, Watt A, et al. Fundamental movement skills and physical fitness as predictors of physical activity: A 6□year follow□up study. *Scand J Med Sci Sports*. 2016; 26(1):74-81.
32. Wall AT. The developmental skill-learning gap hypothesis: Implications for children with movement difficulties. *Adapt Phys Activ Q*. 2004; 21(3):197-218.
33. Hoeboer J, De Vries S, Krijger-Hombergen M, Wormhoudt R, et al. Validity of an Athletic Skills Track among 6-to 12-year-old children. *J Sports Sci*. 2016; 34(21):2095-105.