ORIGINAL ARTICLE

Changes in Torso Muscle Endurance Profiles in Children Aged 7 to 14 Years: Reference Values

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ABSTRACT. Dejanovic A, Harvey EP, McGill SM. Changes in torso muscle endurance profiles in children aged 7 to 14 years: reference values. Arch Phys Med Rehabil 2012;93: 2295-301.

Objective: To establish torso muscle endurance values in children aged 7 to 14 years, as well as ratios between torso extensors, flexors, and lateral torso flexors, with applications in clinical assessment, rehabilitation, physical education targets, and athletic training program designs. It was hypothesized that boys and girls mature differently in terms of torso muscle endurance.

Design: Measurements of torso muscle endurance were performed by using 4 tests in healthy children.

Setting: Elementary school in Novi Sad, Province of Vojvodina, Republic of Serbia.

Participants: Children from 1 elementary school (N=753, n=394 boys and n=359 girls) were grouped into 8 age strata.

Interventions: Not applicable.

Main Outcome Measures: Four tests established isometric physical endurance: Biering–Sørensen test for extensor endurance, flexor endurance test, and right- and left-side bridge tests. The mean, ratio, standard deviation, and 25th, 50th, and 75th percentile scores were determined for each sex/age stratum.

Results: A 2-way analysis of variance indicated that girls had higher mean endurance times for torso extension and torso flexion than did boys. For example, times measured by using Biering–Sørensen and right-side bridge tests were significantly greater for girls than for boys across all age groups ($P<.023$). Boys can sustain the side torso test longer than can girls. Furthermore, 3-dimensional torso muscle endurance is under significant impact of age. Tukey Honestly Significant Difference post hoc tests confirmed that within and between sex exist significant differences in mean endurance times in all age strata at the significance level $P=.05$.

Conclusion: Both age and sex influence differences in torso endurance in children aged 7 to 14 years. These data of endurance times, their ratios, and percentiles in healthy subjects form a database that may be useful for providing training and rehabilitation targets.

Key Words: Abdominal muscles; Back; Child; Muscle development; Physical endurance; Rehabilitation.

ENDURANCE OF TORSO MUSCLES has been linked to spine health[1-4] and prediction of future back disorders. Studies on adult populations[5-8] suggested that the ability of the trunk muscles to maintain appropriate levels of activation over long periods of time may be more protective than strength development for future back injury. McIntosh et al[9] suggested that static endurance of torso muscles is important for mechanical support, with Kavcic et al[10] adding further insight by quantifying muscles acting as a guidewire system to prevent unstable behavior. Here, prolonged activation rather than strength was needed. In addition, because movement flaws are associated with injury and pain,[4] another possible mechanism was thought to involve the capacity to maintain better movement form during repeated tasks. Prolonged end-range motion has also been shown to occur, with fatigue causing strain and pain in passive tissues together with altered muscle spindle stimulation.[11] These possible mechanisms that explain the link between poor endurance and back pain[12] justify the emphasis on the endurance time of back muscles as an important outcome in developing prevention strategies for low back disorders in children.[13] However, because no data exist on children, this study was conducted to document better isometric endurance scores for each sex/age stratum in children.

Links between torso endurance and injury and performance have been suggested in several studies. For example, Evans et al[14] found that more trunk muscle endurance may play an important role in injury-free performance among athletes. Johnson et al[15] noted that decreased isometric back extensor endurance was associated with the presence of low back pain (LBP) in adolescents aged 11 to 19 years. Also, Andersen et al[16] found that 17-year-old boys and girls with high isometric muscle endurance were less likely to report back pain. More girls than boys experienced LBP, and it was more common in taller adolescents. Interestingly, strength does not appear to have similar links to pain and/or injury as endurance in that LBP does not seem to be associated with maximal isometric trunk muscle strength or body sway in young adults aged 19 years.[17] Salminen et al[18] retrospectively observed that 15-year-olds with and without back pain, and who participated regularly in leisure time physical activities (twice a week or more), had increased spinal mobility, higher isometric endurance of back muscles (tested with modified Biering–Sørensen testing), and higher dynamic strength of the trunk flexors (sit-up testing). Salminen et al[19] documented less incidence of LBP in those with higher isometric back muscle endurance. Geldhof et al[20] confirmed that efficient back function is important to prevent chronic back pain later in life. Jones and Stratton[21]

List of Abbreviations

AbdFle	flexor endurance test
BackEx	back extension test
LBP	low back pain
LsideB	left lateral torso test
RsideB	right lateral torso test

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identified the lack of normative data on muscle function assessment in children and that this should be addressed.

The purpose of this study was to document the range in torso endurance profiles in boys and girls aged 7 to 14 years and to establish a normative database. It was hypothesized that young boys and girls mature differently in terms of endurance profiles, that their torso endurance scores will not match those obtained from an adult population, and that differences in torso endurance exist between boys and girls and change with age.

METHODS

Subjects

This study involved 753 children from 1 Serbian elementary school (394 boys and 359 girls), who were grouped into 8 age groups from 7 to 14 years. Each age stratum contained different numbers of participants. For boys, the numbers of subjects per age stratum were as follows: n=30 (7 years), n=35 (8 years), n=58 (9 years), n=42 (10 years), n=59 (11 years), n=49 (12 years), n=63 (13 years), and n=58 (14 years). For girls, the numbers of subjects per age stratum were as follows: n=41 (7 years), n=38 (8 years), n=50 (9 years), n=42 (10 years), n=58 (11 years), n=43 (12 years), n=45 (13 years), and n=42 (14 years).

The testing and data collection methods were presented to, and approved by, the Parents' Committee of the Elementary School (Novi Sad, Republic of Serbia) as well as to the Teaching and Scientific Council of the Faculty of Sport and Physical Education, Department for Applied Kinesiology, University of Nis (Nis, Republic of Serbia). All parents signed the informed consent form prior to data collection. To reduce the risk of injury or psychological distress, each test was explained and demonstrated in front of the children as a measure of familiarization. Prior to each test, participants warmed up for 15 minutes under the supervision of the physical education teacher. Only 1 endurance test was conducted per session to avoid influences of fatigue. The inclusion criteria for participants were as follows: (1) 7 to 14 years of age, (2) no neurological or orthopedic problems of the spine or hips, (3) no upper- or lower-extremity disorders, and (4) needed to feel healthy prior to testing, which was confirmed verbally.

Data Collection

Four tests (presented in random order) were used to establish isometric torso muscle endurance after McGill et al[3]: Biering–Sørensen test, flexor endurance test (AbdFle), and left and right lateral torso tests (LsideB and RsideB) (figs 1–3). McGill[3] found these tests to be reliable (with a reliability coefficient of >.97) when tested consecutively over a 5-day period. In addition, Evans et al[14] documented that these lateral endurance tests have high reliability. Time was measured with a stopwatch (Microsplit MS200, TAG Heuer).[a] During each test, 2 assistants were present with each subject to ensure proper form for safety and injury prevention reasons. The assistants were trained during pilot testing together with receiving and reading a manual with the explanation of tests.

Fig 1. Back extension endurance test (BackEx).

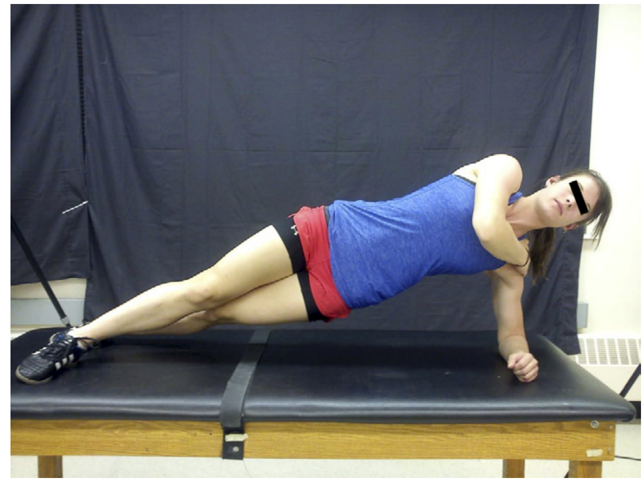


Fig 2. Lateral side endurance tests (RsideB and LsideB).

Back extension test (BackEx). Back muscle endurance followed the original Biering–Sørensen position, with the body cantilevered out over the end of a test bench (1500×1100×500mm), the arms crossed on the chest, and the pelvis, knees, and hips secured with straps. The test ended when the subject lost a horizontal position or when a maximum time of 300 seconds was reached. During the test, the subjects were allowed to be verbally corrected twice to maintain the proper position (see fig 1).

Lateral torso tests (LsideB and RsideB). Lateral torso endurance was tested with the subject lying in the full side-bridge position; the legs were held straight with the top foot placed in the front of the lower foot and the participant held his/her body in a straight line by using his/her elbow. The test was terminated when the subject lost a straight posture or when a maximum time of 300 seconds was reached (see fig 2).

Flexor endurance test (AbdFle). In this test, subjects adopted a sit-up position, with the arms crossed on the chest and the hands placed on the opposite shoulders. The feet were secured under toe straps or held by an assistant, and the back

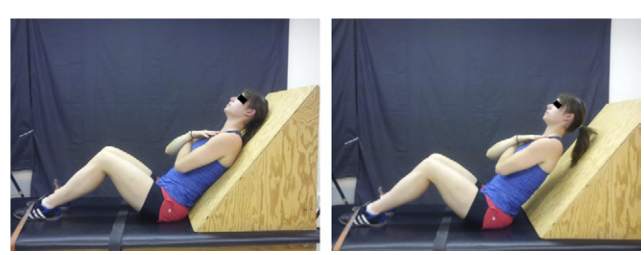


Fig 3. Flexor endurance test (AbdFle).

Table 1: Test Variables, Mean, and Percentile Reference Values for 3-Dimensional Torso Muscle Endurance Tests of All the Subjects, by Age and Sex

Subjects				Endurance Time (s)						
Age (y)	TMEt	Sex	n	Mean ± SD	Mean Ratio	Minimum	25th Percentile	Median	75th Percentile	Maximum
7	BackEx	B	30	110.8±59.6	1.0	42.0	68.0	104.0	138.0	300.0
		G	41	111.0±44.5	1.0	40.0	70.5	113.0	146.5	214.0
	AbdFle	B	30	76.0±51.2	0.69	18.0	49.0	63.5	86.7	249.0
		G	41	96.5±75.8	0.86	24.0	46.0	71.0	121.0	300.0
	LsideB	B	30	62.3±32.0	0.56	24.0	36.7	55.0	83.2	138.0
		G	41	56.9±21.4	0.51	22.0	40.5	51.0	72.0	110.0
	RsideB	B	30	66.0±27.6	0.59	29.0	41.0	65.5	83.2	142.0
		G	41	59.0±22.0	0.53	25.0	43.0	56.0	71.5	116.0
8	BackEx	B	35	126.1±67.9	1.0	40.0	73.3	120.0	156.0	300.0
		G	38	137.0±64.6	1.0	55.0	82.5	126.0	182.2	300.0
	AbdFle	B	35	140.6±87.2	1.11	37.0	68.0	111.0	193.0	300.0
		G	38	100.7±80.9	0.73	28.0	45.7	66.5	121.2	300.0
	LsideB	B	35	59.9±26.3	0.47	25.0	38.0	60.0	69.0	121.0
		G	38	44.7±24.6	0.32	18.0	28.7	37.0	53.2	130.0
	RsideB	B	35	60.0±24.6	0.47	25.0	46.0	52.0	76.0	127.0
		G	38	53.8±24.5	0.39	23.0	35.7	49.0	70.2	125.0
9	BackEx	B	58	150.7±63.3	1.0	45.0	102.7	141.5	190.5	284.0
		G	50	191.6±62.9	1.0	104.0	138.2	183.0	245.5	300.0
	AbdFle	B	58	147.8±91.4	0.98	18.0	72.5	125.5	214.0	300.0
		G	50	168.6±95.2	0.87	30.0	74.7	154.0	275.5	300.0
	LsideB	B	58	74.4±40.6	0.49	23.0	51.7	66.0	90.0	300.0
		G	50	84.4±38.8	0.44	27.0	55.2	77.0	98.2	190.0
	RsideB	B	58	84.5±54.7	0.56	20.0	47.5	71.5	103.7	300.0
		G	50	77.6±42.9	0.40	20.0	52.0	68.5	87.5	256.0
10	BackEx	B	42	165.1±68.6	1.0	46.0	105.7	154.5	211.7	300.0
		G	42	202.1±65.6	1.0	87.0	148.7	190.5	258.7	300.0
	AbdFle	B	42	137.9±74.6	0.83	34.0	77.0	124.5	165.5	300.0
		G	42	149.0±81.4	0.73	56.0	80.7	122.0	205.7	300.0
	LsideB	B	42	81.9±44.5	0.50	21.0	48.2	73.0	108.0	236.0
		G	42	85.8±38.8	0.42	18.0	56.2	75.0	114.7	181.0
	RsideB	B	42	88.5±42.4	0.53	20.0	56.2	79.0	116.7	208.0
		G	42	95.9±46.8	0.47	30.0	58.7	86.0	125.0	262.0
11	BackEx	B	59	160.2±67.4	1.0	55.0	109.0	145.0	191.0	300.0
		G	58	182.0±67.8	1.0	63.0	126.2	164.0	234.0	300.0
	AbdFle	B	59	129.2±78.9	0.80	25.0	71.0	119.0	151.0	300.0
		G	58	111.0±69.2	0.60	31.0	57.0	90.0	146.7	300.0
	LsideB	B	59	72.3±30.8	0.45	30.0	49.0	68.0	91.0	165.0
		G	58	77.5±39.0	0.42	26.0	49.7	71.0	91.2	171.0
	RsideB	B	59	76.8±30.9	0.47	24.0	53.0	72.0	93.0	164.0
		G	58	76.0±27.9	0.41	17.0	55.7	72.5	93.5	152.0
12	BackEx	B	49	169.1±64.1	1.0	72.0	124.0	149.0	209.5	300.0
		G	43	210.3±59.6	1.0	77.0	168.0	206.0	256.0	300.0
	AbdFle	B	49	124.4±69.3	0.73	15.0	74.5	106.0	170.5	300.0
		G	43	126.1±64.2	0.59	42.0	78.0	114.0	151.0	300.0
	LsideB	B	49	71.9±36.1	0.42	16.0	42.5	68.0	94.0	164.0
		G	43	68.4±32.0	0.32	32.0	48.0	56.0	89.0	178.0
	RsideB	B	49	79.9±38.2	0.47	13.0	50.0	74.0	103.0	173.0
		G	43	64.8±24.8	0.30	33.0	49.0	66.0	76.0	156.0
13	BackEx	B	63	182.9±70.1	1.0	64.0	119.0	180.0	248.0	300.0
		G	45	206.3±57.8	1.0	112.0	158.5	196.0	249.5	300.0
	AbdFle	B	63	138.7±71.6	0.75	41.0	86.0	117.0	175.0	300.0
		G	45	148.2±79.1	0.71	29.0	86.0	120.0	205.5	300.0
	LsideB	B	63	84.4±32.4	0.46	14.0	60.0	82.0	106.0	161.0
		G	45	75.7±29.2	0.36	42.0	51.5	68.0	93.5	184.0
	RsideB	B	63	88.9±31.1	0.48	42.0	64.0	80.0	109.0	199.0
		G	45	80.2±33.9	0.38	30.0	57.5	70.0	94.5	207.0
14	BackEx	B	58	181.4±59.7	1.0	79.0	139.2	177.0	209.0	300.0
		G	42	197.5±72.7	1.0	43.0	147.5	199.0	257.0	300.0
	AbdFle	B	58	154.9±75.6	0.85	42.0	89.7	138.0	206.0	300.0
		G	42	140.8±72.3	0.71	37.0	87.7	117.5	185.5	300.0

Table 1 (Cont'd): Test Variables, Mean, and Percentile Reference Values for 3-Dimensional Torso Muscle Endurance Tests of All the Subjects, by Age and Sex

Subjects				Endurance Time (s)						
Age (y)	TMEt	Sex	n	Mean ± SD	Mean Ratio	Minimum	25th Percentile	Median	75th Percentile	Maximum
	LsideB	B	58	94.9±43.9	0.52	29.0	64.0	87.0	115.0	280.0
		G	42	86.0±32.1	0.43	43.0	63.7	80.0	100.5	188.0
	RsideB	B	58	97.6±38.3	0.53	40.0	69.7	88.5	112.2	202.0
		G	42	86.0±35.2	0.43	40.0	60.7	79.5	103.2	203.0

NOTE. N=753. The mean ratio represents the test score over the back extension score. Minimum and maximum columns indicate the range of the scores, and percentile columns represent the value of endurance in seconds of that particular percentile.
Abbreviations: B, boys; G, girls; TMEt, test for torso muscle endurance.

rested against a plywood box angled 50° from the floor. Knees and hips were flexed 90°. To begin, the box was pulled back 10cm while the subject held the sit-up position as long as possible. Failure occurred when the subjects' back touched the box or when a maximum time of 300 seconds was reached (see fig 3).

Data Analyses

Qualitative classifications of endurance were as follows: less than 25th percentile represented poor endurance, 25th to 49th percentile represented an average endurance, 50th percentile considered as good, and greater than 75th percentile considered as excellent endurance values. The mean, ratios of different endurance scores, and standard deviations of the 25th, 50th, and 75th percentile scores were determined for each age category by age. A 1-way analysis of variance was used to establish mean torso endurance differences within the group of boys and girls separately. A 2-way analysis of variance evaluated the impact of sex and age on torso muscle endurance. Tukey Honestly Significant Difference post hoc tests were used to compare differences of mean torso endurance scores between boys and girls, with the significance level set at $P<.05$. Statistical analyses were conducted by using SPSS statistics/software.[b]

RESULTS

The mean endurance values for tests, ratio for endurance times with back extension scores as base, and percentile data for the muscle endurance tests about the 3 axes of all participants by sex and age are listed in table 1. The means are graphically displayed in figures 4 to 6.

Difference Between Boys and Girls Aged 7 to 14 Years

Sex had an impact on BackEx ($F(1737)=25.3$, $P<.001$) and RsideB ($F=5.2$, $P<.023$) between boys and girls aged 7 to 14 years. Furthermore, age influenced BackEx ($F(7737)=17.5$, $P<.001$), AbdFle ($F=7.1$, $P<.001$), RsideB ($F=10.5$, $P<.001$), and LsideB ($F=10.3$, $P<.001$). These results are summarized in table 2.

Specifically, BackEx scores in both boys and girls aged 7 and 8 years were lower than those in boys and girls aged 9 to 14 years ($P<.05$). For AbdFle scores, 3 homogeneous subsets formed: boys and girls aged 7, 8, and 11 years; boys and girls aged 10, 12, 13, and 14 years; and boys and girls aged 9 years ($P<.05$).

LsideB scores in boys and girls aged 7 years were lower than those in boys and girls aged 9, 10, 13, and 14 years. Also, 8-year-old boys and girls had significantly lower mean endurance values than did all other age groups ($P=.001$), but not the 7-year-olds ($P=.923$). Boys and girls aged 12 years had lower LsideB times than did 14-year-olds. Similarly, the group aged 13 years had lower LsideB times than did the group aged 14 years. RsideB analysis revealed that boys and girls aged 7, 8, 11, and 12 years shared the same endurance profile while the group aged 9, 10, 13, and 14 years had higher scores ($P<.05$).

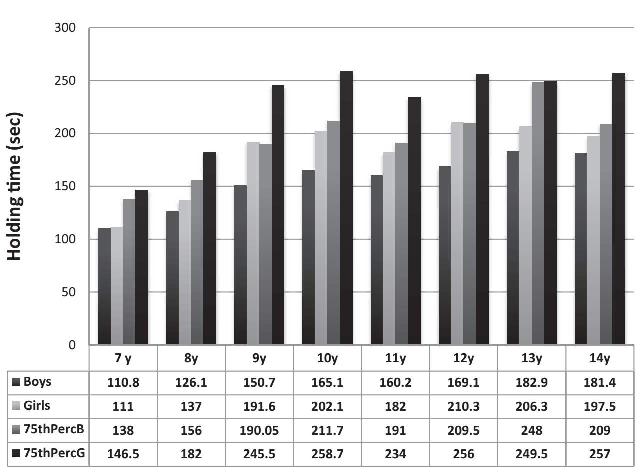


Fig 4. Back extension endurance mean values (in seconds) together with the 75th percentile scores for boys and girls aged 7 to 14 years. Abbreviations: 75thPercB, 75th percentile boys; 75thPercG, 75th percentile girls.

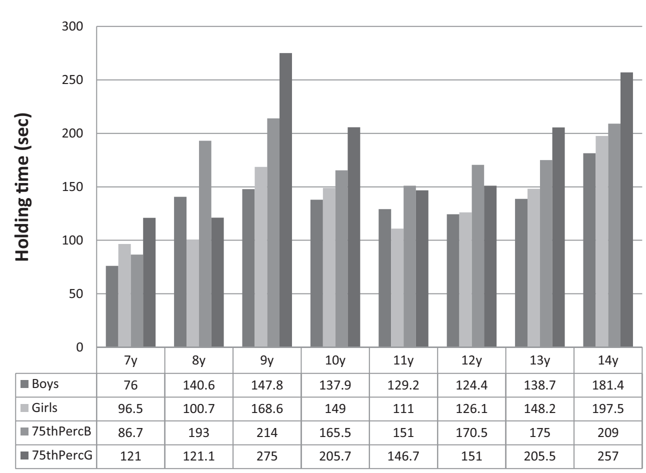
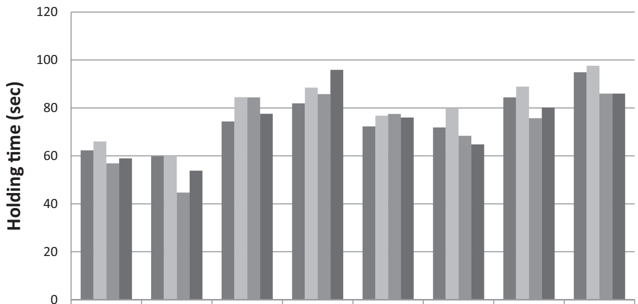


Fig 5. Torso flexor endurance mean values (in seconds) together with the 75th percentile scores for boys and girls aged 7 to 14 years. Abbreviations: 75thPercB, 75th percentile boys; 75thPercG, 75th percentile girls.



	7y	8y	9y	10y	11y	12y	13y	14y
BoysLs	62.3	59.9	74.4	81.9	72.3	71.9	84.4	94.9
BoysRs	66	60	84.5	88.5	76.8	79.9	88.9	97.6
GirlsLs	56.9	44.7	84.4	85.8	77.5	68.4	75.7	86
GirlsRs	59	53.8	77.6	95.9	76	64.8	80.2	86

Fig 6. Lateral side endurance mean values (in seconds) together with the 75th percentile scores for boys and girls aged 7 to 14 years. Abbreviations: Ls, left side; Rs, right side.

The minimum statistically significant difference for BackEx between boys and girls aged 7 to 14 years was 37.9 seconds ($P<.003$) (table 3); for AbdFle, it was 37.2 seconds ($P<.008$); for LsideB, it was 16.3 seconds ($P<.016$); and for RsideB, it was 15.7 seconds ($P<.045$).

Difference Within Boys Aged From 7 to 14 Years

Within boys aged 7 to 14 years, differences existed in BackEx ($F(7386)=6.1$, $P<.001$), AbdFle ($F=3.6$, $P<.001$), LsideB ($F=4.5$, $P<.001$), and RsideB ($F=4.5$, $P<.001$).

Specifically, boys aged 7 years had lower mean endurance times than did boys aged 10 to 14 years ($P<.05$). Also, boys aged 8 years had lower mean endurance times of back muscles than did boys aged 13 and 14 years. Interestingly, 9-year-old boys had results no different from those of all other boys aged 7 to 14 years. Thus, boys aged 7, 8, and 9 years belong to 1 back muscle endurance profile.

The LsideB showed that boys aged 7 years scored lower than boys aged 14 years ($P<.002$). Boys aged 8 years had lower LsideB scores than did boys 13 and 14 years old, and boys aged 12 years scored lower than boys 14 years old ($P<.05$). Boys aged 9 and 10 years were not different from the other aged boys. The RsideB showed that boys aged 7 years scored lower than boys aged 14 years ($P<.006$). Boys aged 8 years scored lower than boys aged 10, 13, and 14 years. Boys aged 9, 11, and 12 years were not different from the other boys and form the same endurance profile group.

The minimum statistically significant difference between means in BackEx for the boys aged 7 to 14 was 49.4 seconds ($P<.019$); in AbdFle, it was 53.25 seconds ($P=.044$); in LsideB, it was 22.6 seconds ($P<.021$); and in RsideB, it was 28.5 seconds ($P<.025$) (see table 3).

Difference Within Girls Aged 7 to 14 Years

Within girls aged 7 to 14 years, differences existed in BackEx ($F(7351)=13.8$, $P<.001$), AbdFle ($F=4.9$, $P<.001$), LsideB ($F=8.3$, $P<.001$), and RsideB ($F=7.2$, $P<.001$).

Specifically, BackEx scores in girls aged 7 years were lower than those in girls aged 9, 10, 11, 12, 13, and 14 years ($P<.001$). Girls aged 8 years also scored lower than girls aged 9, 10, 11, 12, 13, and 14 years ($P<.001$). Girls aged 7 and 8 years belonged to the same back muscle endurance group. AbdFle scores were lower in girls aged 7 years than in girls aged 9, 10, and 14 years ($P<.05$). Girls aged 9 years scored higher than girls aged 7, 8, and 11 years. Girls aged 12 and 14 years belonged to the same profile group and had no significantly different results from the other girls ($P<.05$).

In the LsideB, girls aged 7 years scored lower than girls aged 9, 10, and 14 years ($P<.002$). A subset of girls aged 8 years scored lower than girls aged 9, 10, 11, 12, 13, and 14 years ($P<.05$). In the RsideB, girls aged 7 years scored lower than girls aged 10 ($P<.001$) and 14 ($P<.007$) years. Girls aged 8 years scored lower than girls aged 9, 10, 11, 12, 13, and 14 years ($P<.05$).

The minimum statistically significant difference between means in BackEx for the girls aged 7 to 14 years was 45 seconds ($P<.014$); in AbdFle, it was 51.6 seconds ($P<.047$); in LsideB, it was 23.7 seconds ($P<.031$); and in RsideB, it was 22.2 seconds ($P<.035$).

DISCUSSION

To our knowledge, this is the first study that cataloged the distribution of torso endurance scores in children aged 7 to 14 years for the tests reported here. Given the links between endurance and injury resilience and calls for characterizing endurance scores in children, this may be considered a reference data set. One hypothesis was that age and sex affect endurance scores—this was true. Generally speaking, girls across the ages scored higher than boys in back extension and flexion endurance but not in the lateral musculature. However, within the sexes, interesting trends emerged, suggesting differential roles of maturation. For example, boys formed 2 clusters for back endurance—7 to 10 years and 11 to 14 years—but they peaked later than girls because the same minimum significant difference occurred in girls at 9 years of age as for boys at 10 years of age.

The second hypothesis speculated that children have different torso endurance scores than do adults. McGill et al[3] tested 75 adult (31 men and 44 women; mean age ± SD, 23±2.9y)

Table 2: Summary of 2-Way Analysis of Variance: Impact of Age and Sex on Mean Torso Muscle Endurance (in Seconds) in Boys and Girls Aged 7 to 14 Years

Variable for Boys	Mean Holding Time(s)	SD	F	P
BackExt	170.3	69.7	17.5*	.001
			25.3†	.001
AbdFle	132.7	79.6	7.1*	.001
LsideB	75.3	36.8	10.5*	.001
RsideB	78.7	37.6	10.3*	.001
			5.2†	.023

NOTE. N=753.
*Impact of age on the dependent variable.
†Impact of sex on the dependent variable.

Table 3: Summary of Tukey Honestly Significant Difference Post Hoc Multiple Comparisons of Torso Muscular Endurance Tests With Minimum Statistically Significant Mean Differences Among the Participants in the Different Sex Groups

TMEt	Sex	Number	Minimum Statistically Significant Mean Difference (s)	*P*	95% Confidence Interval
BackEx	B	394	49.4	.019	4.693–94.115
	G	359	45.0	.014	5.325–84.744
	B-G	753	37.9	.003	8.424–67.376
AbdFle	B	394	53.2	.044	0.779–105.731
	G	359	51.6	.047	0.401–102.877
	B-G	753	37.2	.008	5.893–68.588
LsideB	B	394	22.6	.021	1.891–43.362
	G	359	23.7	.031	1.196–46.313
	B-G	753	16.3	.016	1.768–30.863
RsideB	B	394	28.5	.025	2.014–55.034
	G	359	22.2	.035	0.867–43.534
	B-G	753	15.7	.045	0.170–31.417

Abbreviations: B, boys; B-G, mean endurance time difference between boys and girls; G, girls; TMEt, test for torso muscle endurance.

university undergraduate students and documented the mean back endurance test time of 146 and 189 seconds for men and women, respectively. Data in the current study documented average mean endurance for back extension in 7-year-old boys and girls to be much lower than that in 14-year-olds. This relation between 7- and 14-year-old children and the 21-year-old adults held for flexor endurance. However, the side bridge scores in the 7-year-olds were lower than those in the adults, but the scores in 14-year-olds were comparable with those in the adults (96 seconds for men and 76 seconds for women when right and left sides were averaged).

Furthermore, interesting findings were noticed in the lateral side bridge test (LsideB and RsideB) scores. Both sexes aged 7 to 8 years were characterized with decreased values in side torso muscles. Girls achieved very low values (32% for the left side and 39% for the right side) of their back extensor times. However, by ages 9 to 10 years, there appears to be a period of increasing mean side torso endurance. From 11 to 12 years, a decrease in side torso values was observed especially in girls who achieved the lowest ratio of 32% in the left side and 30% in the right side of their back extensor time. Finally, 13- to 14-year-olds demonstrated increased side torso endurance. This addresses 2 major questions of this study.

According to Alaranta et al,[22] endurance capabilities of the back extensor muscles are important, even more important than strength, in the prevention and treatment of LBP in adults. Furthermore, Balague et al[23] did not establish a relation between isokinetic trunk muscle strength and history of LBP in 10- to 16-year-olds.

There are several data sets to compare with the results of this study. Geldhof et al[20] documented quite similar times for children aged 8 to 11 years in BackEx (152 seconds) and lower values in AbdFle (71 seconds). Reiman et al,[24] in their study of high school athletes, reported higher mean back endurance times than scores in the boys of this study at the group level, but they achieved lower scores in mean flexion endurance time. Leetun et al[25] found that boys aged 19 years had higher scores for lateral torso endurance (84.5 seconds) compared with their female counterparts (58 seconds), although sex differences were not as large in the children of this study.

Study Limitations

There are some limitations to be considered for interpreting the data of this study. Results were obtained and limited to Serbian children, although there is no reason to assume they are not typical of modern children worldwide. There was the possible influence of personal factors—motivation, for example, which may or may not complicate the interpretation of the results. However, the children were given full information about the tests, together with encouragement during testing. Finally, the subjects were not separated into athletic and nonathletic groups. Parallel testing was conducted to encourage true scores by way of competition.

CONCLUSIONS

Boys and girls have different torso endurance profiles, with girls generally having better scores in the sagittal plane (AbdFle and BackEx) but poorer scores in the frontal plane (LsideB and RsideB). Girls also appear to develop sagittal plane endurance sooner than do boys. Our results indicate that children achieved different torso endurance profiles as compared with the available data on adults. These data of endurance times, ratios, and percentiles in healthy children may be useful for providing training targets in sport, rehabilitation of low back disorders, and lumbar spine injury prevention. These normative data may be used to compare a subject's score at intake or as an outcome measure in clinical practice for children and young athletes. They may also prove useful in the future for understanding the developmental mechanisms of pain. These data may be helpful for designing age- and sex-appropriate exercise approaches.

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Suppliers

a. Microsplit MS200; Tag Heuer, 6A Rue Louis-Joseph Chevrolet, 2300 La Chaux de Fonds, Switzerland.
b. SPSS statistics; SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.